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ORIGINAL ARTICLES.

I.—On the Discovery of a Secondary Reptile in Madagascar: *Steneosaurus Baroni* (n. sp.); with a Reference to some Post-Tertiary Vertebrate Remains from the same Country recently acquired by the British Museum (Natural History).

By R. Bullen Newton, F.G.S.

(PLATE IX.)

THE Rev. Richard Baron, F.G.S., of the London Missionary Society, has sent to the British Museum some interesting reptilian remains from the Jurassic rocks of Madagascar, which he obtained during 1891, at Andranosamonta village, a locality situated in the north-western part of the Island. They were enclosed in a tenacious shelly limestone, so that before their examination could be proceeded with it was necessary to submit them to careful development and cleaning, a work which has been most ably carried out by Mr. Richard Hall, the Assistant Formatore of the Geological Department. The fragments thus relieved represent some of the more prominent parts of a skull belonging to the same animal, comprising:—

(1) An imperfect cranial rostrum, Pl. IX. Figs. 1 & 2.
(2) An almost complete mandible, Pl. IX. Figs. 3 & 4.
(3) Certain posterior parts of the cranium.

There is also a dermal scute, which although somewhat differently localized, *viz.* two miles south of Andranosamonta, is presumed to be a relic of this same reptile, Pl. IX. Fig. 5.

In glancing at the main features of this animal we note its possession of a narrow and elongate rostrum set with numerous alveoli, slightly differing in size, and having a more or less circular periphery.

The teeth are conical, obliquely set, and directed anteriorly; the base of one, showing through the lower surface of the mandible, exhibits a smooth carina on one of its exposed sides.

The premaxillæ unite to the maxillæ on the palatal surface by a well-marked rectangular suture, which terminates above in a deep posterior angle.

Among the chief characteristics of the mandible may be mentioned its long and narrow symphysis occupied by the splenial element, extending anteriorly to within 30 centimetres of the front.

The posterior portions of the head remaining in the matrix indicate a fairly well-defined occipital region consisting of an

obtusely-angled quadrilateral supra-occipital, a transversely elliptical *foramen magnum*, and a tolerably extensive condyle, which is unfortunately imperfect and damaged through fracture.

The front view exhibits a strong parietal ridge, separating two large temporal fossæ, and having beneath a prominently arched pterygoidal vacuity.

The scute is thick, deeply pitted, with an imbricating end, which probably proves its relationship to the ventral armour. Its dimensions are 5·5 by 3·5 cent. with a thickness of 1·5 cent.

A consideration of these details proves conclusively that we are dealing with a reptile possessing Crocodilian affinities, and from its produced snout bearing a strong resemblance to the existing Gharial (*Gavialis*) of the Ganges, though differing very widely from it in other and more important characters. It is not till we go back much further in time that we find its congener among the Mesozoic Crocodiles forming the family of the Teleosauridæ. In comparing the generic peculiarities of this group, it is ascertained that in *Teleosaurus* the teeth are directed outwards, striated near the base, and without the two vertical carinæ; it has also a triangularly shaped supra-occipital. *Teleidosaurus* possesses a broad and short rostrum, few teeth, three dental alveoli only to each premaxilla, and a small circular occipital foramen and condyle.

In Geoffroy St. Hilaire's genus *Steneosaurus*,[1] as restricted by Deslongchamps[2] and adopted at the present day by Mr. R. Lydekker,[3] we recognize characters which will include the Malagasy specimen, *viz.* the presence of a long snout furnished with numerous bi-carinated teeth, obliquely set; a long, narrow, mandibular symphysis; extensive temporal fossæ; an obtusely quadrangular supra-occipital; and a transversely elliptical *foramen magnum*.

Description of the Remains.[4]

The *Cranial rostrum* is elongate, narrow, cylindrical and undulating; posterior end incomplete. It measures 37·5 centimetres in length, and graduates in width from 3·3 cent. at the præmaxillo maxillary constriction to nearly 5 cent. at the fifteenth maxillary alveolus, with a section at the transverse fracture of 4 by 3 cent.

A fragment in the matrix, which probably represents the posterior extension of the maxillary region, has a length of 19 cent., and in immediate proximity to this is a long, slender, curved bone, which appears to be the quadrato-jugal, measuring 23·5 cent. These dimensions added together give 80 cent., or rather more than $2\frac{1}{2}$ feet as the approximate extent of the entire cranium.

The right maxilla has 25 alveoli, including the six posterior ones,

[1] Mémoires du Muséum, Paris, 1825, vol. xii. p. 146.

[2] Notes Paléontologiques, 1867, p. 126.

[3] Catalogue Fossil Reptilia, British Museum, 1888, part i. p. 108.

[4] The author wishes to record his indebtedness to Mr. R. Lydekker, B.A., F.G.S., and to Mr. A. S. Woodward, F.G.S., for many valuable suggestions offered him during the preparation of this description.

contained in the portion attached to the limestone; the left has 16 alveoli; therefore calculating 4 for each præmaxilla we may roughly assume that the total number of teeth for this animal was from 116 to 120.

The alveolar cavities are large, round, of a slightly varying diameter, and separated by wide and excavated interspaces which produce rather bold marginal serrations; the palatal surface lies just below the alveoli.

The præmaxillæ are swollen and truncated, but so mutilated in front that only the first and second alveoli are traceable on each side; the suture follows a rectangular course on the palatal surface, then passes closely by the first maxillary alveolus to continue its direction over the upper surface, where it makes a deep posterior descent and terminates in an acute angle.

At the transverse fracture of the rostrum the narial passage is observed to be cordiform in shape, with the apex pointing upwards; the obliquely set condition of the teeth can be also seen here.

The *Mandible* is long and narrow with a depressed dentary plateau, basal surface slightly convex and with vertical sides; it measures 62 centimetres in length, has a maximum thickness of 3 cent., and the posterior ends of the splenials are 13 cent. apart. The mandibular rostrum is widest at the 23rd alveolus where it measures 6 cent., gradually decreasing to half that width at the 6th and 7th alveoli. The dentaries dilate at the 3rd and 4th alveoli, afterwards tapering off to the part containing the two anterior sockets; a somewhat deep groove at the anterior end forms their dividing line.

The symphysis is elongate and narrow, its anterior point being distant 30 cent. from the front. The splenial bones are crushed in their central parts, but well defined anteriorly and posteriorly. Their divergent ends are embedded in the matrix.

The left dentary shows 26 alveoli, a few of the posterior ones being displaced and seen in the matrix; the alveoli similarly arranged as in the cranial rostrum, except the 3rd and 4th, which are contiguous and occupy the elevated and expanded region of the dentaries. The basal portion of the 3rd left dentary tooth is exposed on the under surface of the mandible and exhibits one of its lateral carinæ, which is smooth and not serrated.

The nutrient foramina are fairly distinguishable along the alveolar borders of both rostra.

Cranial Remains in Matrix.

These consist of the occipital region, considerably damaged in parts, having a central vertical depth of 10·5 cent., and a maximum width of about 24 cent.

The upper occipital is concave and quadrilateral, with obtuse angles possessing a similar depth and width of 3·7 cent. The *foramen magnum* is transversely elliptical, having a diameter of 4 by 1·4 cent.; the occipital condyle is large, with an imperfect and broken surface. To the right of the foramen is a distinct perforation,

which probably marks the passage of the pneumo-gastric nerve. The extremities of the lower occipital through injury are difficult to define. The anterior view of this part of the cranium shows a strong parietal ridge, extending about 10 cent. and separating the large temporal fossæ, the front portions of which are absent; width of the right fossa is 7 cent.; height from the top of the parietal ridge to the pterygoidal vacuity is 9·5 cent.; this vacuity is strongly arched and measures at its greatest diameter 5·6 cent.

All other parts of the cranium, such as the orbits, frontals, nasals, palatines, etc., are unfortunately missing.

Specific Affinities.

Comparing this specimen with some of the described species of *Steneosaurus*, we may observe that *S. Larteti* though of somewhat similar dimensions has a larger number of teeth, a straight cranial rostrum, and a rather more depressed head.

S. Stephani possesses more extensive temporal fossæ and larger alveoli.

S. megistorhynchus exhibits a much more extended and depressed cranium as well as more numerous teeth.

S. megarhinus differs in having five alveoli to each præmaxilla.

Not finding its exact representative among these various species, I propose to regard it as a new form, and this chiefly on account of its very narrow and cylindrical rostrum together with its marked undulation. The name proposed for the specimen is *Steneosaurus Baroni*, out of compliment to its discoverer.

The genus *Steneosaurus* has hitherto been restricted to British and European areas, so that the discovery of this reptile so far south as the Island of Madagascar is a matter of the highest interest when considering its geographical distribution. Sooner or later we shall hope to hear of its occurrence in the Jurassic rocks of the African continent, either in the neighbourhood of Mombasa or further northwards among the Antalo Limestones of Abyssinia.

Horizon.—As far as can be ascertained this genus has never been found out of Jurassic deposits. The few Molluscan shells associated with this new specimen tend to prove it of Lower Oolite age. These will be described elsewhere; in the meantime they may be referred to as (1) *Mytilus*, resembling *M. Tigrensis*, W. T. Blanford, from Abyssinia; (2) *Modiola*, similar in some characters to *M. imbricata*, Sowerby; (3) *Perna*, related to *P. quadrata*, Phillips; and (4) a new species of *Trochactæonina*.

EXPLANATION OF PLATE IX.

Fig. 1. *Steneosaurus Baroni*, sp. nov. Palatal view of the cranial rostrum.
,, 2. Left lateral aspect of the cranial rostrum showing its undulating character.
,, 3. Upper view of mandible, showing symphysis, splenials, etc.
,, 4. Basal view of mandible.
,, 5. Fragment of a dermal scute belonging to the ventral armour.

Figs. 1–4 are $\frac{1}{4}$ nat. size. Fig. 5 is $\frac{1}{2}$ nat. size.

Post-Tertiary Vertebrates from Madagascar.

The British Museum has just acquired an interesting series of vertebrate remains from a Post-Tertiary deposit in Madagascar. They were obtained by the Rev. James Wills, another member of the London Missionary Society, at Sirabé, in the Province of Betsileo, which is marked on Dr. Mullen's[1] Map at 19° 50′ S. and 47° 10′ E. This locality lies in a region of extinct volcanic craters, and according to the maps has an elevation at this point of 4930 feet above sea-level. Thermal springs are also common in the neighbourhood; one at Betafo registering 130° Fahr.

The bones are of a dark brown colour and were found in a swampy deposit of a more or less peaty nature, probably forming the floor of the same dried-up ancient lake—mentioned by the Rev. R. Baron[2] as existing at this spot, and in which some years ago the late Dr. Hildebrandt[3] discovered the skull and skeleton of a Hippopotamus. These remains have been identified as follows:—

Crocodilus robustus, Grandidier and Vaillant.[4]

Æpyornis maximus, Geoffroy St. Hilaire.[5]

Hippopotamus Lemerlei, Grandidier and Milne Edwards.[6]

The same species of Crocodile[7] still abounds in the rivers of the country; but the Æpyornis and Hippopotamus are thought to be extinct, a view which may subsequently be disproved when more is ascertained concerning the unexplored parts of the island. The Hippopotamus bones indicate an animal of rather small dimensions, representing an intermediate form between the ordinary *H. amphibius* and *H. Liberiensis*, a pygmy species indigenous to the rivers of Western Africa.

It may be of interest to mention that sixty years ago Sir Roderick Murchison[8] announced to the Geological Society the discovery of a Hippopotamus tusk and molar tooth in a recent conglomerate rock from Madagascar.

No egg-shells were found associated with the Æpyornis bones, though their occurrence in the alluvial soil of the southern portions of the coast-line has long been recognized, some of them attaining to an enormous size. One example in the British Museum has a

[1] On the Central Provinces of Madagascar, Journ. Roy. Geogr. Soc. 1875, vol. xlv. p. 139, map.

[2] Notes on the Geology of Madagascar, Q.J.G.S., 1889, vol. xlv. p. 308.

[3] Skizze zu einem Bilde central-Madagassischen Natur-lebens im Frühling. Zeitsch. Ges. Erdk. Berlin, 1881, vol. xvi. p. 194.

[4] Sur le crocodile fossile d'Amboulinsatre (Madagascar), Comptes Rendus, 1872, vol. lxxv. p. 150.

[5] Notice sur des ossements et des œufs trouvés à Madagascar dans des alluvions modernes et provenant d'un oiseau gigantesque, Ann. Sci. Nat. (Paris), 1850, ser. 3, vol. xiv. p. 206.

[6] Sur les découvertes zoologiques faites récemment à Madagascar par M. Alfred Grandidier, Comptes Rendus, 1868, vol. lxvii. p. 1165.

[7] G. A. Boulenger, Cat. Chelonians and Crocodiles in the British Museum, 1889, p. 286.

[8] Proc. Geol. Soc. Lond. 1833, vol. i. No. 31, p. 479. The specimen here referred to is in the Museum of the Geological Society, and is localised as 30 miles from Antananarivo (see MS. label).

maximum circumference and girth of 36 and 30 inches respectively, with a liquid capacity of rather more than two gallons; it has been noticed by Capellini in the Mem. Acad. Inst. Bologna, 1889, ser. 4, vol. x. p. 16.

Although relics of an exactly similar fauna have been made known from contemporaneous beds nearer the sea-border, particularly at Ambulisatra, on the south-west coast, considerable importance is to be attached to their occurrence inland, and in the centre of an extinct volcanic area. It must not, however, be forgotten that, as previously stated, Dr. Hildebrandt's discovery of 1881 will rank as the first record of vertebrate remains from this special locality.

Lastly, allusion may be made to the occurrence of Tortoise remains in the Quaternary deposits of Madagascar. Two finely-preserved carapaces of gigantic size have recently been added to the Geological Gallery of the British Museum. They were obtained by Mr. Last, off the south-west coast of the island, in a cavern two miles from the sea, where they were found embedded in a loose, sandy soil. Mr. G. A. Boulenger[1] has identified them as *Testudo Grandidieri*, Vaillant,[2] an extinct species most nearly allied to the existing *Testudo gigantea*, Schweigger,[3] of the Aldabra Islands, an uninhabited group to the north-west of Madagascar.

This comprises all the vertebrates at present known from the later Tertiary formations of Madagascar. There are, doubtless, many others yet to be disentombed, as the past fauna of this island could not possibly have been of so restricted a character as to consist merely of a Crocodile, a Tortoise, a Bird and a Mammal. Fresh discoveries are sure to follow on a more detailed investigation of these beds, and collectors would do well to remember that the history of *Æpyornis* still remains incomplete as the skull and other important parts of its skeleton are not yet known to science. It is hoped that the chiefs of the Malagasy tribes may place no impediments in the way of explorers who are endeavouring to obtain these buried relics relating to, so interesting a subject as, the extinct fauna of their country.

II. — On some Palæozoic Phyllopodous and other Fossils.

By Prof. T. Rupert Jones, F.R.S. and Dr. Hy. Woodward, F.R.S.

(PLATE X.)

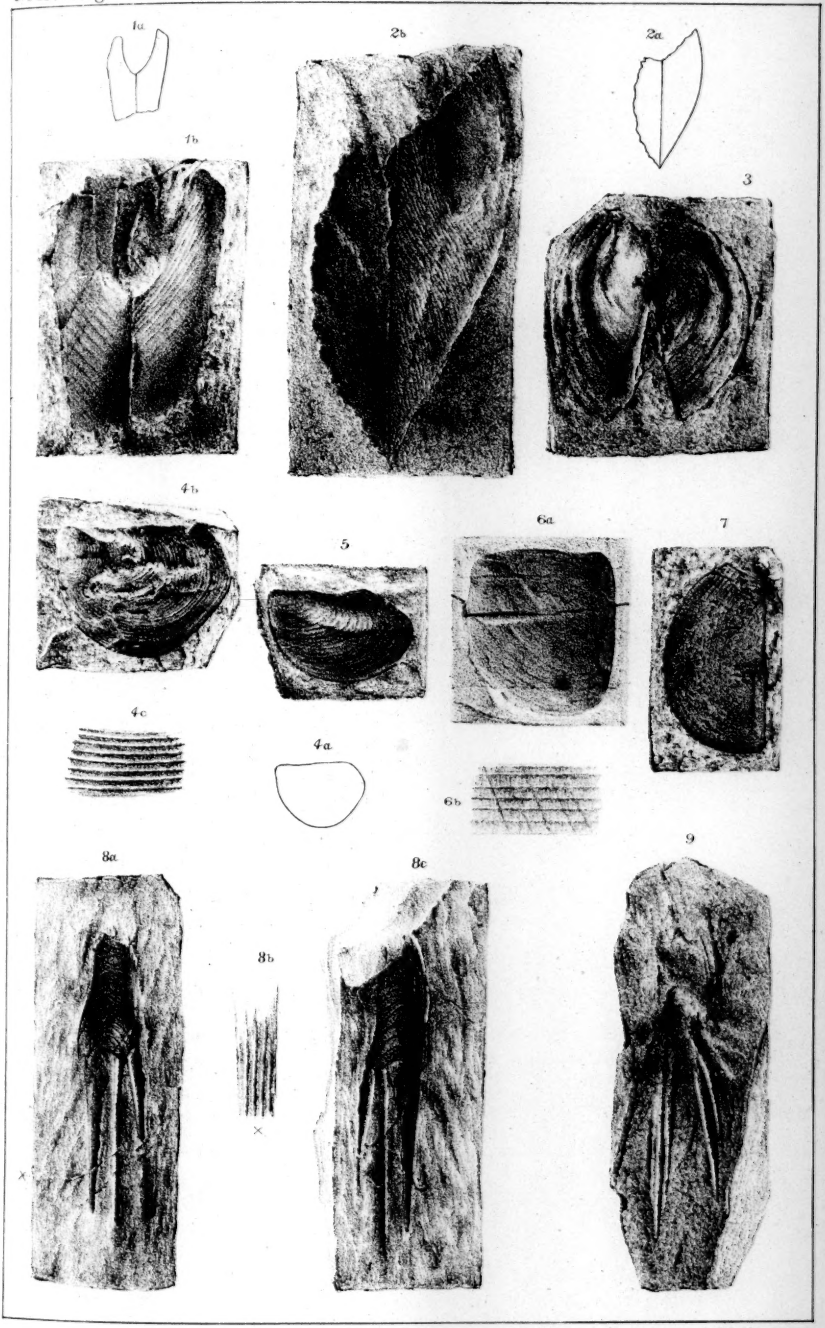
SOME of this miscellaneous series of old fossils have been in the collections in the British Museum many years; but, owing to their small size and doubtful characters, they have not found an abiding place in any special zoological group.

Others have been lately submitted to us for examination by Mr. G. J. Williams, F.G.S., of Blaenau Ffestiniog; and four of these have decidedly Phyllopodous or Phyllocaridal alliances.

[1] Proc. Zool. Soc. London, 1893, part 4, p. 581.

[2] Remarques complémentaires sur les Tortues gigantesques de Madagascar, Comptes Rendus, 1885, vol. c. p. 874.

[3] Prodromi monographiæ Cheloniorum, 1814, p. 58.



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PALÆOZOIC PHYLLOPODS &c.

Another specimen, belonging to the Woodwardian Museum at Cambridge, was long ago figured and described by the late Mr. J. W. Salter as probably belonging to a Ceratiocarid. Lastly, an enigmatical fossil, possibly belonging to one of the Crustacean groups, has been lent by the Owens College, Manchester, and is illustrated in the text.

1. Peltocaris Salteriana, sp. nov. Plate X. Figs. 1*a*, 1*b*.

This specimen shows two imperfect valves, lying in contact along the dorsal sulcus, with a deep semi-oval nuchal notch; and in these features corresponding with the genus *Peltocaris*. The surface-ornament consists of strongly-marked subconcentric striæ, oblique, form in front backwards and inwards, on each valve; and much wider apart on the left valve than on the other, possibly from the loss of one or more layers of the test.

Each valve is partially imbedded at the ends and on the edges; and the left valve is broken in front. Pieces of the broken test roughen the nuchal space. As this differs from any species which we know, both as to shape and the obliquity of the lines of growth, we propose to distinguish it as *Peltocaris Salteriana*, thus naming it after the original founder of the genus.

Fig. 1 is one of the two counterparts, which are dark films of a fragmentary carapace, 11 mm. long and 7 mm. wide, in hard dark-grey shale of the Lower Tremadoc series. From a small quarry on the stream flowing North from Moel Llyfnant, seven miles E.S.E. of Ffestiniog. Mr. G. J. Williams' Collection.

2. Conularia (fragment). Plate X. Figs. 2*a*, 2*b*.

This obscure specimen has, at first sight, the appearance of two imperfect valves or moieties of an *Aptychopsis*, very acute posteriorly, and retaining the attenuated posterior extremity of a nuchal notch, at the front end of a dorsal suture. The superficial ornament, however, is not at all concentric, but almost uniformly oblique across the two moieties of the fossil, and bending in at the central line. This sculpturing seems to agree with the markings on the two sides of a small imperfectly preserved *Conularia*. The greatest length of the relic is 18 mm. and the width 9 mm.

Fig. 2 is a dark film, on hard dark-grey shale, weathering reddish on one face, from Llechwedd Deiliog quarry, about six miles East of Ffestiniog, on the Ffestiniog-Bala road. Arenig formation. Mr. G. J. Williams' Collection.

3. Dipterocaris Etheridgei, T. R. J. and H. W. Pl. X. Fig. 3.

Peltocaris (?), sp. ind., Nicholson and Etheridge. Monograph Silur. Foss. Girvan District, Ayrshire, vol. i. 1880, p. 212, pl. 14, fig. 21.

Dipterocaris Etheridgei, T. R. J. and H. W. Geol. Mag. 1884, pp. 349 and 353; Brit. Assoc. Report for 1884 (1885), pp. 75, 78, and 85.

This little fossil (Fig. 3) shows two "alæ," or wing-like moieties, not sutured[1] together at their narrow junction, nearly semi-circular

[1] "Anchylosed and without hingement," in Mr. J. M. Clarke's well-preserved specimens described and figured in the "Amer. Journ. Sci. ser. 3, vol. xxv. p. 121.

on the outer edge, and on the inside bounded by oblique edges, two (below) meeting near the centre at an angle of about 25°, and two (above) at an angle of 60°.

This differs but little from the last-mentioned specimen, found in the Penwhapple Burn, Girvan, except in being larger and more symmetrical—that is, less distorted. Hence the two appear to belong to one and the same species; and their geological stages are not very far apart, for the Girvan species came from the Penkill Beds, as mentioned in the Table at pp. 235–6 of the "Monograph" alluded to above, which are referred to the "lower part of the Upper Silurian,"—that is, to the "Upper Llandovery or May Hill Sandstone," see page 227 of the "Monograph."

This form is similar in essential particulars to Mr. J. M. Clarke's Devonian *Dipterocaris pennæ-Dædali* (*op. cit.* p. 123, fig. 1); but differs from it in the two *alæ*, taken together, having a rounded outline, and the posterior cleft is not so widely open. The British form is also much smaller. From *D. Procue*, Clarke, and *D. pescervæ*, Clarke, it differs still more in several respects.

Fig. 3 is a dark film, slightly thickened, and whiter on the outer curve of each valve, and at each end of the left valve; it also has some ferruginous thickenings at the centre and elsewhere. On a hard dark-grey shale, of Upper Silurian (Salopian) age, from Penyglog quarry, Corwen, on the border of Counties Merioneth and Denbigh, North Wales, Mr. G. J. Williams' collection.

		Left *ala* of the Girvan specimen according to the figure.
Greatest length of the right-hand moiety or *ala* ...	28 mm.	... 12 mm.
Greatest width ,, ,, ,, ...	12 ,,	... 4½ ,,
Length of the posterior cleft or notch	15 ,,	... 6 ,,
Length of the anterior ,, ,, ...	about 6 ,,	... 4½ ,,
Median junctural interval	about 6 ,,	... 1 ,,

4. Mytiloid Shells. Plate X. Figs. 4*a*, *b*, *c*, and 5.

These were selected some time ago as having an Estherioid appearance; but, under the microscope, the evidence of such an alliance disappears. Our Figs. 4 and 5 approximate to some of the Silurian *Mytili* described and figured by Barrande in his "Syst. Silur. Bohême," vol. vi. such as pl. 210, figs. 1, 4, 5, and 6, *M. consors*, and fig. VI. 6, *M. longior*.

Figs. 4*a*, *b*, *c*, represent a black film, somewhat crumpled and broken on the upper edge; it shows very delicate concentric lines of growth. On a hard black shale; British Museum, No. 48762; without a locality; from the "Bright Collection."

The valve is 6 mm. long, and 4 mm. high.

Fig. 5. A black film on dark-grey, hard shale, with ferruginous face. A small portion of the shell or test remains at the apex. British Museum, No. I. 2612. Probably from the Tremadoc Slates; no locality.

The valve is 20 mm. long, and 12 mm. high.

The junction is obscure in the figure given of the similar fossil in Nicholson and Etheridge's "Monograph of the Silurian Fossils of the Girvan District in Ayrshire," vol. i. 1880, p. 212, pl. 14, fig. 21.

5. Fragments of a Phyllocarid ? Plate X. Figs. 6*a*, 6*b*.

This was selected as being possibly an imperfect valve or moiety of a Phyllopodous carapace; but we find that the evidences of its alliance in any direction are too poor to allow of critical determination. Mr. J. W. Salter labelled it "*Lingula*," possibly with the view of its being an imperfect triangular shell, the upper right-hand corner in Fig. 6*a* being regarded as at or near the umbo; the striæ, however, are not really concentric with that angle. Some effects of lateral pressure are seen in the oblique parallel lines crossing the lines of growth in Fig. 6*b*.

Fig. 6 is a black film on black shale, from the Lowest Llandeilo beds at Abereiddy Bay, Cardiganshire. British Museum, No. I. 2611.

6. Aptychopsis Williamsii, sp. nov. Plate X. Fig. 7.

This is the moiety of a carapace near to those of *Aptychopsis ovata*,[1] J. & W., and *A. Wilsoni*,[2] H. W., but differing from each in the curve of the outer edge, and in the proportion and angle of the nuchal notch. In particular, this valve has a relatively fuller curve posteriorly, and is narrower in the upper part, than either of those above-mentioned. The uppermost edge has been somewhat damaged, like our figure of *A. Salteri*, H. W.[3]

At first sight, when looked at with its straight edge uppermost, this simulates a valve of *Ceratiocaris Ruthveniana*[4] with a broken anterior end; the striate ornament, however, consists of concentric, and not longitudinal, lines, and the posterior extremity is more angular. We name it in honour of its discoverer, Mr. G. J. Williams of Blaenau Ffestiniog.

Fig. 7 represents a dark film in dark-grey, rather hard shale, from Harp Hollow near Welspool, of Upper-Silurian age. Mr. G. J. Williams' Collection.

Left valve—Length, 26 mm.; Width, 13 mm.; Depth of notch, about 5 mm.; Length of dorsal suture, 22 mm.

The nuchal notch opens at an angle of about 120°.

7. Ceratiocaris insperata, Salter. Plate X. Figs. 8*a*, *b*, *c*, and 9.

Ceratiocaris ? insperatus, Salter, Mem. Geol. Surv. vol. iii, 1866, p. 295, woodcut, fig. 6; 2nd edit. 1881, p. 486, woodcut, fig. 6.
——— ——— —— In "Siluria," 3rd (4th) edit. 1867, p. 516.
——— ——— —— Catal. C. S. Foss. Cambridge, 1873, p. 16.
——— ——— H. Woodward, Catal. Brit. Foss. Crust. 1877, p. 71.
——— *insperata*, T. R. J. and H. W., Geol. Mag. 1885, p. 466; Brit. Assoc. Report for 1885 (1886), p. 351.
——— ——— ——— Monograph Brit. Palæoz. Phyllop. part i. 1888, p. 64.
——— ——— H. Woods. Catal. Type Foss. Woodw. Mus. Cambridge, 1891, p. 134.

Fig. 8, in a fairly good state of preservation, shows three caudal spines (one style and two stylets), and the distal portion of a sub-

[1] Monograph Brit. Palæoz. Phyllop. part ii. 1892, p. 108, pl. 15, figs. 4 and 5.
[2] *Ibid.* p. 105, pl. 15, figs. 12, 15 and 16.
[3] *Ibid.* pl. 17, fig. 6.
[4] *Ibid.* part i. 1888, p. 49, pl. 10, fig. 6.

cylindrical telson, or last abdominal segment. This has left a strong, black, shining film, bearing irregular chevron-like marks, with their angles pointing upwards. These have some resemblance to the ornamentation of the style of *Phasganocaris pugio* (Barrande), as figured by Novák in the Sitzsb. böhm. Gesell. Wissen. 1886, pl. 1, figs. 5, 7, 12, and 14; but the telson of that species has the leaf-like ornament present on some of the *Ceratiocarides*, and not the angular striation of the present form (fig. 8).

The longest or middle spine is bulbous at the top, fitting into the end of the telson; and the two stylets appear to be articulated to the lateral angles, where the end of the telson widens out. The longitudinal striæ (fig. 8*b*.), such as one of these two lateral spines exhibits, may have characterized the others; and the central spine (style) seems to have been strongly ridged along its median line.

As far as the materials serve, we think that fig. 8 may well be of the same genus and species as fig. 9 (*C. insperata*).

Fig. 8*a* and *b*, two counterparts (natural size), black shining films, on hard dark-grey shale, of the Arenig series, from Llechwedd Deiliog quarry, about six miles E. of Ffestiniog.

Greatest length of specimen, 41 mm. Length of the fragment of the last abdominal segment, 16 mm. Greatest width of the last abdominal segment (at its distal end), 7 mm. Least width (at the proximal end of the fragment), 4 mm. Length of one stylet, 22·5 mm. Length of the other, not so well exposed, 21 mm. Length of the style (middle spine), 26 mm.; width at its head (proximal end), 4 mm.

The obscure appearances of other lateral spines, in fig. 8*a*, are quite adventitious, being due to the irregular surface of the shale, as seen more clearly in fig. 8*c*.

Fig. 9 is a careful illustration of the fossil described and figured by Salter, and preserved in the Woodwardian Museum at Cambridge. The trifid caudal appendage is clearly shown in the natural impression; and two at least of the spines appear to have been ridged or fluted. The telson is obscurely indicated.

Fig. 10. An impression or cast (natural size) in dark-grey hard shale from the Upper-Tremadoc series, at the railway-cutting above Penmorfa, Portmadoc. Collected by Mr. D. Humfrey.

Middle spine (style), 28 mm. long. Outside spines (stylets), about 18 mm. long. Width of the end of the telson, about 7 mm.

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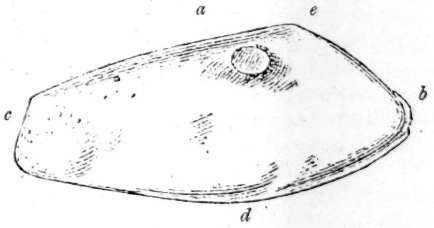
8. The subtrigonal, probably crustacean, test here figured came from the Upper Silurian beds at Church Hill, Leintwardine, near Ludlow, and is preserved in the Owens College Museum, Manchester.

Length of the fossil, 53 mm.; its greatest width, 23 mm.; its least width, 10 mm.

Taking the straight edge (*a*) as indicating a dorsal border at top, we see that each end of the fossil has a sloping edge,—one (*b*) much longer, and sloping at a lower angle (45°) than the short steep slope (*c*) at the other end (60°). This last turns rapidly to the

third border (*d*), which swells out with a broad curve to meet the other sloping edge (*b*) first mentioned. Near the angle (*e*), between the last mentioned and the straight edge, is a round spot, which may have been the base of a large prickle or outstanding spine; and the surface of the other (narrower) part of the test is besprinkled with minute spots, which may have been the bases of small prickles.

If looked at as being possibly the valve of a *Ceratiocaris*, it does not agree in outline and features with any known species, and its markings are foreign to that genus. The only approximate analogue is the somewhat apocryphal figures or diagrams in "Siluria," 1857, p. 262, Fossils (65), 1 and 2, with which we cannot as yet collate exactly any specimens.



Another, but even more doubtful analogue, may be perhaps seen in the outline of A. S. Packard's *Cryptozoë problematica*, Proceed. Amer. Phil. Soc. vol. xxiii. 1886, p. 380, fig. 1.

If our specimen be placed with the slope, *e*, *b*, upwards, it might possibly be regarded as the right valve of an *Aptychopsis* were it not that the lower edge, *c*, would form one side of a posterior notch strange to that genus, and the surface-marks would also be abnormal.

Some such posterior notch exists in *Dipterocaris* and its allies; but the moieties or alæ of their carapaces not being sutured, coalesce at the junction.

We must therefore leave this interesting, but enigmatical, fossil to some future investigation before we can decide upon its characters and alliance.

DESCRIPTION OF PLATE X.

Fig. 1. *Peltocaris Salteriana*, sp. nov., *a*, natural size; *b*, magnified 3 diameters.
,, 2. Fragment of a *Conularia*, *a*, nat. size; *b*, magn. 3 diam.
,, 3. *Dipterocaris Etheridgei*, T. R. J. and H. W., nat. size.
,, 4. Mytiloid shell, *a*, nat. size; *b*, magn. 2 diam.; *c*, ornament, magn. 15 diam.
,, 5. Mytiloid shell, natural size.
,, 6. Fragment of a Phyllocarid ? *a*, nat. size; *b*, ornament, magn. 15 diam.
,, 7. *Aptychopsis Williamsii*, sp. nov. Left valve; nat. size.
,, 8. *Ceratiocaris insperata*, Salter. Two counterparts, *a* and *c*, nat. size; *b*, ornament on one of the stylets, magn. 3 diam.
,, 9. *Ceratiocaris insperata*, Salter. Impression; nat. size.

III.—On Some Quartz-schists from the Alps.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

A THICK mass of bedded schists, as I have described in more than one paper,[1] occupies the highest position among the so-called metamorphic rocks of the Alps. With the exception of some gneisses—so far as I know of a porphyritic character, and almost certainly intrusive granites modified by pressure—and various green schists, which, in part at least, are basic igneous rocks, similarly affected,[2] the group, which may be traced from one end of the chain to the other, consists of altered sediments. Calcareous mica-schists are its most abundant members. The commonest types are dark schists varying from lead colour to black (the *Thon-schiefer* or *Thon-glimmer-schiefer* of many Continental authors) from which the calcite sometimes disappears, and greyish schists in which there is not much mica (the *kalkhaltig glimmer-schiefer* of the same, which locally becomes a white marble[3]). Quartz-schists also occur, sometimes merely as laminæ alternating with the darker mica-schists—like sand and clay in certain stratified rocks—sometimes in beds. These, so far as I know, are of moderate thickness and white in colour.

That the various schists are associated exactly as are shales, limestones, and sands in ordinary stratified masses cannot, I think, be doubted.[4] The persistence of lithological types over large areas is often remarkable; even the peculiar black mica-schist with dark garnets can be traced, to my knowledge, for more than thirty miles along the general strike of the group.[5] Still changes occur, especially in the transverse direction. The group of dark-coloured mica-schist, of which the above-named garnet-bearing rock is a member, occupies a broad strip for some miles E.N.E of Monte Leone, but for a considerable distance west of that mountain the rocks become lighter in colour, and the darker type is restricted to the northern margin. We perceive the change if we ascend towards the Simplon Pass from the Rhone Valley; it is even more marked, if we extend our examination up the Vispthal as far as the outlying masses of the same group near the range of Monte Rosa.

The quartz-schists, so far as I know, are not always present and are generally of subordinate importance. But they occur at intervals over a considerable part of the chain. My collection contains specimens from the neighbourhood of Windisch Matrey (*i.e.* very near the Gross Glockner) to the district of the Great St. Bernard.[6] But I purpose to restrict my description mainly to the quartz-schists which occur in the neighbourhood of Saas-Fee, since here I have studied them in more detail. In this neighbourhood

[1] Q.J.G.S. vol. xlii. (Presid. Address) xlv. p. 67; vol. xlvi. p. 187.
[2] Q.J.G.S. vol. xlix. p. 94.
[3] Sometimes dolomitic.
[4] I have examined them more or less minutely, over various Alpine regions, from the Viso to the Gross-Glockner.
[5] Q.J.G.S. vol. xlvi. p. 199, etc.
[6] I have not been east of the former among the crystalline schists, nor found them west of the latter in any journey made since I began to pay minute attention to the Alpine schists.

the calc-mica-schist group is obviously folded up in a very complicated fashion between the underlying gneissose rocks.[1] The gigantic undulations rise and fall for thousands of feet. It is no exaggeration to say that an active climber in a single day might touch the schists at points separated by a mile vertical. I know of outcrops on the same path which differ in elevation by full 3000 feet.[2] But to describe in detail either these folds or the varieties of the calc-mica-schists[3] would occupy too much space; on the present occasion I must restrict myself to the quartz-schists.

This is a rock macroscopically very well characterized. It is a compact white quartz-rock,[4] containing a variable quantity of silvery mica, which is sometimes grey coloured. The latter mineral not seldom is almost absent from bands an inch or so thick; then it may become abundant, forming sometimes a layer hardly thicker than a sheet of letter paper, sometimes distinct bands in thickness, running up to about half an inch (seldom reaching one inch), when the rock, strictly speaking, consists of alternating layers of white quartz-schist and lead-grey or greenish-grey mica-schist. In weathering it shows a marked tendency to break up into slabs. This, for instance, is very conspicuous in the quartz-schists which crop out on the craggy slopes west of the hotels at Saas-Fee. The talus below is strewn with slabs about as thick as the tiles used in flooring an outhouse. The laminæ of mica determine their separation, so that the surface sparkles with little scattered flakes of this mineral, and the thicker blocks may be further split up with the hammer. The basset edges of the rock can be recognized at once by their peculiar "flaggy" aspect and sharp, almost rectangular, jointing. In this section, as usual, the quartz-schist is associated with varieties of the calc-mica-schist, in which the mica is generally subordinated as much as in the quartz-schist. The change from the one rock to the other is rapid, but the calc-schist is often more micaceous in the immediate vicinity of the quartz-schist. The former becomes in places an almost pure marble; sometimes also it is quite "slaty," fine-grained, crumbling, and of a bluish-grey colour, at first sight very like some of the Mesozoic limestones of the Alps. The resemblance is the result of pressure;[5] the real difference becomes apparent on careful examination.

The general relations of these schists are readily determined, but some minor questions are by no means easy to settle. It is quite clear that the mass, as a whole, is infolded between moderately coarse rather micaceous gneiss, of a type common in the district. The latter, often considerably crushed, may be seen cropping out in places both below and above, extending in the latter direction right

[1] It was my intention to give some particulars of these gneisses, but they would make the article too long, so I reserve them for a future communication.

[2] Between Saas-Fee and Saas im-Grund and on the peak of the Mittaghorn.

[3] Many details are given in the papers to which reference has already been made.

[4] I avoid the term quartzite for reasons which will presently appear.

[5] Other instances may be found both in this district and elsewhere in the Alps. The effect of pressure in crystalline limestones is discussed in this MAGAZINE, 1889, p. 483.

up to the mountain crests;[1] but it is difficult to ascertain the exact nature of the fold. In one place—just west of the hotels—we found only two outcrops of the quartz-schists; but further away to the south (working towards the shoulder overlooking the stream from the Hochbalm Glacier) two other bands of quartz-schists made their appearance, one seemingly above and one below the higher of the former outcrops. Have we here a double fold or are some other beds intercalated? There is something to be said for each view, and as the matter is of little moment I did not attempt to work it out in detail.[2] On the opposite side of the above-named stream we find, at the base of the mountain-buttress corresponding with the one just described (in descending order), calc-mica-schist, and below this two bands of quartz-schist, the higher about 10 feet, the lower about 8 feet thick, separated by about 3 feet of calc-mica-schist, very micaceous in lower part, saccharoidal, with thin mica-layers, in upper. As the bands of quartz-schist mentioned in the previous description at least are many yards apart, one of them (probably the highest)[3] appears to be locally split up by a calcareous band; lower down, after some more calc-mica-schist, is another band of quartz-schist. The same rocks also occur on the Fee-Gletscher alp—further to the south-west.

Another section occurs on the opposite side of the valley in which Saas-Fee stands, which requires some description. This is on the north-eastern part of the Mittaghorn.[4] Here we found in one place the quartz-schist separated from the gneiss by a fairly thick zone of calc-mica-schist; the latter then thins gradually out (as the path *descends*) till the quartz-schist is in contact with the gneiss. After this has happened the quartz-schist is thrown into S-like curves, and in one place a mass of calc-schist only a few feet thick remains infolded in the top part of the letter. The quartz-schist in contact with the gneiss is micaceous, contains some elongated spots like a felspar, and seems as if it passed rapidly into the gneiss, which is somewhat affected by pressure, is not a coarse-grained variety, and contains (in larger amount) a similar mica. The annexed section may serve to make the relation clearer. Evidently the quartz-schist

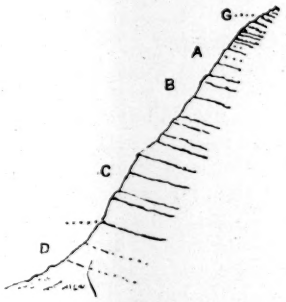
[1] It is indicated as correctly as the scale permits on the Swiss map, sheet xxiii. Here the gneiss above is distinguished from that below. There are some differences, but I think that we may regard them as of minor importance, and the gneiss broadly as one group.

[2] To give an idea of the possible complication I may mention that in one place we found a small patch of a cavernous, yellowish, soft, calcareous rock, containing numerous fragments from the calc-schist group. It *might* have been a tufa; but the position made this interpretation improbable, and I strongly suspect it was the last remains of an infold of rauchwacke (Trias). This rock is mapped as here and there in the middle of the crystallines in this part of the Pennines, always in mere strips, and with the once overlying Jurassic rocks wholly gone.

[3] I refer only to the *apparent* position.

[4] The path from Saas-Fee ascends and crosses the northern spur of the Mittaghorn and then runs for some little time along the eastern face at a height probably of rather more than 3000 feet above the Saas-thal. The sections described are found soon after the corner is turned, but the calc-mica-schist and quartz-schist can be also seen for some distance running obliquely down the western slope of the mountain.

is unconformable with the gneiss, so the question to be determined is whether the latter is an older rock than the former, or is an intrusive granite which has been afterwards crushed into a gneiss. The quartz-schist certainly becomes more micaceous as it approaches the gneiss, and I thought that here and there I could detect in it indications of larger quartz grains.



G seems to quadrate in A and A into B the last and C are varieties of quartz-schist and certainly pass one into the other; the passage from C to D about the dotted line is quick.

Specimens were secured for microscopic examination, which may be now described. It will be convenient to take first the normal quartz-schist, such as occurs at c in the section, and with this specimens of similar rock from other localities may be included. These flaggy quartz-schists consist almost entirely of quartz and mica, with an occasional grain of felspar, which, however, is sometimes all but absent.[1] The quartz grains vary in size in the different specimens, but are commonly less than ·02″. Usually they are distinctly longer in the direction of the foliation, their outline is irregular, sometimes ragged, giving a characteristic "clotted" look; occasionally, if the nicols be used, one tint, especially where the grains run small, seems to predominate in the slide. No trace of a nucleus can be detected in the grains, which exhibit the peculiar mosaic structure often seen in the more quartzose layers of the mica-schists of the same group. Minute fluid cavities with relatively small bubbles are rather numerous.[2] They are more abundant near, but not restricted to, the junction of grains. The mica flakes range from about ·04″ downwards in length, being frequently about ·03″, though in some slides smaller scales, say about ·01″, are common. With transmitted light, they vary from a slightly olive-grey to colourless. Dichroism, if any, is very faint; they are, in the former case, a little greener with vibrations parallel to the basal plane. The ends are often rather irregular, but sometimes the flakes

[1] Small zircons, occasional grains of iron oxide, probably also of z isite, may be detected, but on these it is needless to dwell, as they have no apparent bearing on the history of the rock.

[2] Most of these require a one-eighth objective and many can only just be seen with that; some are irregular in form, the majority oval.

are a little lenticular in outline, as if slightly nipped. In a specimen from the south side of the Lukmannier Pass, where thin laminæ of mica alternate repeatedly with layers of quartz, and the rock macroscopically shows beautiful flexures, it is clear that the folding took place after the foliation had been produced. The grains of felspar are often a little larger than the quartz, but of the same general form. As a rule they are more or less decomposed, but not seldom are in fair preservation, showing characteristic twinning, etc.

In regard to the other specimens collected from the Mittaghorn; two were taken respectively 6 feet and 10 feet from the one already mentioned; the second near to the seeming passage of the quartz-schist into the gneiss. They are more micaceous than the former one, and the first is rather gneissic in aspect, as if some felspar were present. On microscopic examination that proves to be the case. The felspar grains, far from numerous, are irregular in outline like the quartz, and are rather decomposed. Two or three of them are about ·07″ in diameter, while the quartz grains seldom exceed and are often less than ·01″. The second specimen only differs from that already described in being distinctly more micaceous, and in having its quartz grains a shade smaller. In this but little felspar is recognizable though a disseminated brown dust gives the slide a less clear aspect. A fourth specimen was taken at a distance of about 100 yards, very close to the junction with the gneiss; the precise line of demarcation, as already said, being impossible to determine.[1] Here the constituents are decidedly more variable in size. Much of the mica (abundant) is about as large as that in the other slides, but there are many flakes barely ·01″ long. The quartz is occasionally about the same diameter, but as a rule is much smaller. Very little felspar can be recognized, but occasional clouds of brown dust suggest that it may have been present, and the slide as a whole is dirty.[2]

Next as to the relation between the present structure and the pressure which these rocks have undoubtedly undergone. In the cases under immediate consideration, the fissility and the foliation are parallel to the banded structure, so the modifying pressure must have acted at right angles to it. The constituents of the rock do not suggest shearing forces of importance, nor indeed so much "flattening out" as one would anticipate. In some cases no doubt a peculiar clotting and mixing of grains and granules may indicate something of the kind; but in these specimens from the Saas-thal only a moderate amount of mechanical disturbance is suggested. The condition of schists which belong to the same group and occur as fragments in the Rauchwacke (Trias) indicates that the foliation was anterior to the Tertiary mountain-making, so that in all probability these rocks had very nearly arrived at their present

[1] Thus labelled in the field: "seems to be the base of the quartz-schist, just against wrinkled gneiss."

[2] In these slides a few rather irregular grains of a clear mineral are present, which is probably zoisite, and in one garnet (one or two grains of rather fragmental aspect) is probably present.

condition prior to Mesozoic times, and the uprearing of the present Alpine chain only rendered them more fissile and produced occasional flexures.

But in none of these quartz-schists can original fragments be distinguished with certainty. Here and there a clastic structure may be suspected. Here and there an inequality in size may suggest that the larger quartzes either are not authigenous or, if so in a certain sense, only represent the remains of grains which have escaped better than the rest in a general catastrophe. There is nothing to intimate that the mica in its present form is derivative. Like the quartz, it seems either to have formed or at least to have acquired its present outline *in situ*.[1] The few grains of felspar in one specimen most nearly resemble fragments. I cannot detect any structural difference, allowing for the altered proportion of the constituents, between these quartz-schists and some of the mica-schists, such as are found in the same group, and the latter correspond more nearly (though by no means identical) with certain laminated sediments altered by contact metamorphism [2] than with any other rocks known to me.

But these quartz-schists are markedly different from ordinary quartzites.[3] In these either the original sand-grains, though surrounded by an aureole of secondary quartz, can be readily recognized, or the comparatively regular granular structure suggests a clastic origin. So too does the mica, when it occurs. No marked reconstitution of constituents has taken place. A felspar fragment still remains as a fragment; rotten perhaps, but not, as it were, inosculating with a mosaic of quartz and white mica. These quartzites, also even after being subjected to pressure, do not put on, so far as I know, the aspect of *quartz-schists*[4]—in the former the fragmental character of the rock, the cause of its modified structure, are at once apparent. Not so in the quartz-schists; that they were once sandstone, though doubtless true, is only a matter of conjecture; how far they have been affected by pressure is a matter of uncertainty.[5]

[1] The structure of these schists sometimes recalls that of certain of the rocks on the Eastern Gneiss near Kinlochewe, but the structure is coarser, the fragmental character (due in the latter to crushing) is less distinct, as if mineral reconstitution had been more complete in these Alpine rocks.

[2] See Q.J.G.S. vol. xliv. p. 11.

[3] I have not a few slides in my collection, representing, among others, the 'Durness,' Wrekin, Hartshill, Lickey, Stiperstones, Cherbourg, and Ardennes quartzsites.

[4] I am indebted to the kindness of Messrs. Peach and Goodchild, and the favour of Sir A. Geikie, for the opportunity of examining a fine specimen of the 'piped' quartzite (Basal Cambrian) from Glendhu, Sutherlandshire, which has become, through great pressure, slabby and schistose. It exhibits a structure with which I was already familiar from other rocks affected by the great thrust faults of the N.W. Highlands, and this is so different from that of the quartz-schists described in this paper that I could distinguish the one from the other at the first glance through the microscope.

[5] I except, of course, the cases where the rock exhibits flexures. Here it may be added that since the first notes of this paper were written I have had the opportunity of seeing the quartz-rocks near Clifden (Connemara)—a prolongation westward of the Twelve Pins. These in the field reminded me frequently of the Alpine quartz-schists, and always appeared to differ from the Durness quartzite; they seem to be

Again, though these quartzites, just enumerated, are separated from the quartz-schists by distinctive characteristics, we find occasionally rocks which may be said to occupy an intermediate position. Of these I possess only a few examples. Some of the Huronian quartzites, which show no signs of pressure, are now quartz-mica rocks, in which, as I have said,[1] we cannot determine what portion of either mineral is allothigenous, and are led to believe that their present forms were assumed *in situ*. I have found the same structure in a pebble from the basal Cambrian conglomerate at St. David's,[2] and may add that small fragments of quartz-schist are often not uncommon among the oldest coarse grits and conglomerates.

But on grits and shales which have been exposed to the action of important earth movements—such as those which come from the Alps themselves—pressure has produced but moderate effects. Certain of the more minute constituents have undergone micro-mineralogical change; but, generally, of the larger constituents, though certain of the more unstable have been altered, most of them are little affected; even fragments of organisms can still be recognized. In the crystalline masses, zones doubtless occur, here and there, where the effects of crushing are very conspicuous; where, for instance, granitic rocks have been converted into fissile fine-grained mica-schists; rocks also there are (such as some of the pyroxenic group), the constituents of which seem exceptionally unstable under pressure, but many large masses are comparatively little affected. On what grounds, then, when the sedimentary rocks have emerged from the pressure with so little loss of personal identity, are we justified in assuming that the crystalline masses have been completely re-constituted, and that the cases just mentioned, instead of indicating the extreme effects of pressure, represent really its partial effects, that is to say, where crushing has been followed only by partial re-constitution. For any such assertion I cannot find the slightest grounds in the Alps.

So the specimens of quartz-schist discussed above (1) give no proof that their structure was caused by pressure; (2) show that if they have been crushed, great molecular changes have since occurred; (3) afford indirect proof that their structure is pre-Tertiary; (4) are not like Palæozoic rocks which have been crushed. In short, pressure is a most important agent of change, but it is far from being the only one. Dynamometamorphism is a fine-sounding term, but "comfortable words" are more suited for old women than for scientific men.

associated with crystalline schists. Also the quartz-schists in the district near Braemar; some of which occur near to calc-mica-schists, very like those of the Alps, others pass into mica-schists or a kind of gneiss. In microscopic structure both rocks agree in the main with these Alpine quartz-schists. The gneissoid bands seem likely to confirm the idea expressed above that one kind of gneiss may result from the alteration of a quartz-felspar grit, but I must verify some points before I can venture to say more.

[1] Q.J.G.S. vol. xliv. p. 32.

[2] Geol. Mag. Dec. III. Vol. VI. (1889), pp. 315–318.

IV.—On Post-Eocene Surface-Changes in the London Basin.[1]

By A. Irving, B.A., D.Sc. (Lond.), F.G.S.

THE Quarterly Journal of the Geological Society, for 1892,[2] contains a paper by Mr. H. W. Monckton, F.G.S., embodying a useful and valuable collection of observations tending to throw additional light upon the history of the surface-changes, which have taken place in the higher parts of the London Basin in later Tertiary and Quaternary times. The theoretical views put forward in that paper have not, however, altogether the novelty which the author seems to claim for them. He is wrong in coupling my name with that of Prof. Rupert Jones as an advocate of a partial *marine* origin of the gravels, and so claiming novelty for the theory (p. 45) "that all the gravels in the area dealt with were formed after it had for the last time risen above the sea." A few quotations will put this in a clear light.

(*a*) In 1883,[3] I spoke of the plateau-gravels as probably "accumulations produced by powerful river-currents converging possibly to a common estuary" (p. 23), and as having been deposited at a time when "the drainage-system of the area was quite different from that which is seen at the present day" (p. 26). The intermediate pages are mainly occupied with a discussion of the conditions under which I conceived then that their deposition had taken place. More recent observations have but led to the confirmation of that view, and to the dating back of the plateau-gravels to an earlier Tertiary stage than I then ventured to assign them to. I deferred then to the opinion of Prof. Rupert Jones, that the sea had had a share in the deposition of the secondary or terrace-gravels; but more recent and more extended observation compelled me to abandon the idea of marine action, even for them.

(*b*) In 1890,[4] I spoke of the fluviatile transport of the materials from the Wealden uplands to the south, and of the "transport of the angular flint-material by rivers from the Weald across the northward sloping plateau of Eocene land" (p. 558); of the materials being "carried northwards and deposited in lines of river-drainage or spread out on flats, where the declivity of the plateau diminished," comparing this (in a footnote) with my own observations in former years of the "gravelly detritus laid down by Alpine rivers, as they debouch upon the Plain of Bavaria" (p. 559); of their stratification, in most cases as clear as those of the low-level gravels of the present Thames Valley, as "a fact, which seems to point clearly to their river-origin" (p. 560); and of their remaining as "indexes of ancient Pliocene lines of drainage, having preserved the present hills from degradation, while the originally higher ground has been scored with the present valley-system" (p. 561). Other passages of similar import might be quoted from the same paper, and from a

[1] This paper was written some months ago, but has unfortunately been delayed in publication from want of space.—Edit. Geol. Mag.

[2] Q.J.G.S. vol. xlviii. pp. 29–45.

[3] See Proc. Geol. Assoc. vol. viii.

[4] Q.J.G.S. vol. xlvi.

paper (supplementary thereto) which appeared in the GEOLOGICAL MAGAZINE [1] for September, 1890. In this last paper the hypothesis of a terrestrial and fluviatile origin is extended even to the high-level inland gravels of the "Mundesley and Westleton" series of Prof. Prestwich.

(*c*) In 1891,[2] I put forward the same view even more explicitly in the published summary of a lecture delivered at Windsor on "The Geological History of the Thames Valley." There it is pointed out how the maximum elevation of the Wealden axis in Pliocene time, and the correlative "tilting to the north of the Eocene strata of the Tamisian area," probably furnished all the conditions required for the accumulations of the plateau-gravels, and initiated the present Valley of the Thames itself; and a comparison is drawn between this supposed Pliocene set of conditions and those which can be observed *at the present day*, where the Eastern Alpine rivers spread their sheets of detritus over the Tertiary terrain of Bavaria and Würtemberg, owing to the northerly tilting given to it in the last great stage of Alpine elevation. It was from observations of these in my travels of former years, that the terrestrial origin of our plateau-gravels in Berks and Surrey first clearly suggested itself to me.

In this *northerly tilting of the London Tertiaries* is to be found the explanation of what must otherwise appear an anomaly, in the fact that in my 1890 paper I have been able to recognise gravels of the plateau-series down to levels as low as 300′ and even 200′ above O.D. (Bearwood and Farley Hill), while further south I have not been able to bring gravels at a rather higher altitude (with the present geotectonic structure of the country) into the category of the plateau-gravels, as for instance those on Hartford Bridge Flats. To draw the line between the original plateau-gravels and the secondary gravels of the district, which are either wholly or in part derived from the widely-scattered material of the ancient plateau, is no easy matter, for the two seem to merge into one another. Relative altitudes will not settle the matter, for a gravel, which is nothing more than a mass of material reconstructed out of an ancient gravel of the true plateau-series, may be actually at a higher level than one of that series farther north, owing to the general lowering of the gradient of the northward sloping plateau, from the progressive rate of denudation as you ascend from lower to higher altitudes. After some thought on the matter, and trying first one then another test, by which to differentiate the plateau-gravels from the secondary or terrace-gravels (in which category I have included not only the "glacial gravels" but all the "patches of unstratified and angular gravel found on the higher slopes and minor bluffs of the present valleys, mere 'run-of-the-hill' of the later denudation of the country"), I was unable to find any other basis of classification than that which combines both *structure and composition*. And if

[1] "Note on the Elevation of the Weald," GEOL. MAG. Dec. III. Vol. VII. p. 403, *et seq.*

[2] See Science Gossip for May and June, 1891.

under the term "glacial gravels" we include (as I have done all along) those gravelly deposits whose actual structure seems to record the operation of ice as the chief agency, to which the observed structural phenomena are due, we must, as a matter of fact, include in the glacial category many deposits, which might perhaps be excluded therefrom, if we used the term "Glacial" (always mind with a "G") in the narrower and professional sense of the cartographer, which seems to include only those deposits which contain materials foreign to the area in question, such, for example, as the quartzite pebbles derived from the Trias of the Midlands. It is, I imagine, in this narrow and technical sense of the term "Glacial," that the author of the paper referred to at the beginning of this article is inclined to dispute the admission into the glacial series of the contorted gravels and clays at Ninemile Ride, Berks, of which photographs have been taken for the British Association, two of which have been published (one in "Proc. Geol. Assoc," the other in "Science Gossip"), which, moreover, carried the strongest evidence of glacial action, not only to my mind, but to that also of Prof. Spencer, the State Geologist of Georgia (a well-known writer on glaciation), when I took him to the sections in 1890.

Similar contortions and puckering of the well-banded clay (No. 5 of the College well-section) are exposed to view in the deep trench by the birch-avenue leading from the Station to the College, which was dug two winters ago. Considerable masses of gravel (chiefly the wreckage of the pebble-bed) are here also driven down into the clay.

I would remind the reader, that, when it comes to the consideration of a case in which glacial action is involved, the value of individual judgments is to a great extent determined by the knowledge on the part of those who form such judgments, (1) of the actual physical laws concerned in the question under consideration, (2) of the phenomena usually known as "glacial" from personal observation of known glaciated regions, such as those of the Alps and other mountain districts. Were it not that I believe him to have been caught in the technical fallacy indicated above, in his forced and artificially-restricted use of the term "glacial" on pp. 40–41 of his paper, I should consider Mr. Monckton's idea too preposterous to admit of serious discussion.

But the same writer has a way of criticising such caricatures of the ideas or theories or views of another writer, as are creatures of his own imagination. So, without really understanding the theory of the late Prof. Carvill Lewis, of Philadelphia, as to the glaciation of the Mercian and East-Anglian regions, and the relation of that to the glaciation of the Thames Valley, he falls into the mistake of supposing that it requires us to "argue for the presence of the sea in this part of the Thames Valley in Glacial times"; while in reality I have but applied the term "Thames Straits" (as writers before me have spoken of the "Severn Straits") to the broad expanse of water, down which probably ice-floes from the Mercian region floated, through the *higher* part of the Goring-Pangbourne Gorge, which has undoubtedly been much deepened and widened both

during and since the Glacial Epoch. I put the matter very briefly, but plainly, in my Windsor lecture, to which reference has been already made.

Again, on pages 44 and 45 of the paper, with which I am now dealing, this ghost of the sea having "flowed in the Thames Valley since these [Glacial] Gravels [of the north side of the valley] were deposited," is exorcised, in order, as it seems, to enable the writer, who uses the spell, to "reject the theory, which assigns the contortions observed in clay-beds near Wokingham, to bergs or floes of ice, which floated in waters, that filled that valley up to 240′ above O.D." The simple reply is, that those, who, like myself, have adopted such a view, are responsible for what we have said, and not for any extraneous ideas, which another writer's imagination may have read into it. As a matter of fact, and as Mr. Monckton's own testimony (*loc. cit.*) goes to show, we do find just what we should expect in such a submerged shallow valley: we find on the northern slopes glacial detritus; and we find on the southern slopes materials derived immediately from the plateau-gravels and from the strata of the Bagshot terrain of the higher country, to the south, as the outcrops of these receded southwards with the sub-aërial erosion of the district. Both sets of material would be more or less mingled together along a roughly-median zone of such a submerged valley, just as one may often see, in an isoclinal longitudinal valley of a great mountain-chain (such as the Alps) detritus from the crystalline rocks on one flank of the valley mingled together in the most indiscriminate fashion with detritus from the clastic rocks on the other flank, only needing such a widening of the valley by erosive agencies as would admit of such fluviatile action coming into play, as has evidently given us the stratified low-level gravels of the present Thames Valley, which were long ago commented on by one of the most sagacious of British geologists, the late Prof. John Phillips, F.R.S.[1]

One might easily cite the low-level *stratified* drifts of the Severn Valley, and of many another ancient river-valley, as showing this commingling of local materials with glacial *remanié*, were it not that to deal in this way, with what is but a commonplace of physical geology, would only serve to weary the reader. And as the low-level gravels are stratified, so also is it quite an ordinary thing for glacial materials themselves to have been partially stratified; and that without requiring any long "inter-glacial" periods for the supply of the floods necessary to do the work; since the increased fluviatile action arising from the melting of the snow and ice, as the climate gradually underwent amelioration, would be sufficiently potent as an agent for the work to be done. I will only point out here that in the discussion of my paper on the plateau-gravels (*supra cit.*) in the year 1890, it was admitted, that "such contortions as described were generally accepted as evidence of snow or ice," and that by the very person who, in December, 1891, rejects such an explanation of the case then under consideration, yet without bringing forward anything by way of an argument in support

[1] See his "Geology of Oxford and the Valley of the Thames."

of such a change of view, beyond such as is based upon a misunderstanding of the theory under dispute.

There remains to be considered some rather puzzling cases of gravels at rather high altitudes, to which I have hesitated to assign a place among the true plateau-gravels. A reference to my 1890 paper[1] will show that I have omitted the gravels of Hartford Bridge Flats from that category. I rejected them, because, notwithstanding their altitude and even their composition (the same as that of the plateau-gravels), I have never been able to see one, among a dozen or more gravel pit sections on that plateau, which answered to the structural test of *stratification*. Many of them are simply pockets of gravel in the eroded hollows of the Upper Bagshot Sands, as above Cricket Hill, and in every case, where I have seen them exposed, they have given me the impression that, as reconstructed material of an older plateau-gravel, they have been degraded into mere *talus*, or have been lowered by "soil-cap" movement due to the removal of sand from beneath them by the action of "high-level" springs. In many cases erosion of this nature has in course of time been sufficiently concentrated locally for small landslips of inversion to occur; and this is probably the explanation of the curious contorted masses of loamy ferruginous sand, which are so often met with in the gravels, and very often occur near the present surface of the ground at rather high altitudes.[2] I have not much doubt that some such explanation applies to the few exceptional cases of contortion and of the absence of stratification in gravels of the plateau, several of which are cited by Mr. Monckton in his paper. These things being considered, I cannot admit that I have "made too much of the question of stratification and contortion" (p. 35).

It seems to be too little realized often by writers on the superficial geology of this part of England, how great the time interval is, since the plateau-gravels were laid down; and unmindfulness of this seems to make them slow to recognise the great extent and variety of the surface-changes, which must have been brought about by the action of ordinary "meteoric" agencies. Many of these have been long since wholly or partly obliterated; and a very great deal of this kind of erasure of surface-phenomena is no doubt to be referred to the Glacial Period, when the action of certain agencies of change was intensified. Erosion of sands beneath the gravels by high-level springs, and consequent "soil-cap" movement has been already referred to; and a little thought will suffice to show how, in the earlier stages of the sculpture of the present country, small ravines would be developed out of what were at first mere rain-water gullies. As surface-erosion continued, co-operating with the action of springs, numerous small landslips must have occurred, and this would scarcely have happened without the surface-drainage of some of the wider upland valleys being in places impeded, the

[1] Q.J.G.S. (*loc. cit.*) p. 560.

[2] Such contortions in the gravels themselves do not furnish the evidence of glacial action which contortions in the *underlying laminated argillaceous Eocene beds* do furnish.

surface-water being ponded back to form pools and lakes, which, as they got silted up, would form morasses or peat-bogs, some of which actually remain to the present day,[1] and illustrate the operation of the same processes of nature as do many peaty floors of modern valleys in the Alps and elsewhere, where valley-lakes have been silted up.

Among the mineralogical changes which would be brought about under such and similar conditions, would be the formation of limonitic iron-ore and limonitic concretions of sand,[2] in which (as is easy to see) occasional shells of a land- or freshwater-habitat might have been included. One is justified, therefore, in hesitating to accept the occurrence of such limonitic masses in some of the secondary gravels (standing alone) as a part of the wreckage of beds of the Bagshot formation.[3] Again, a little consideration will show that even glauconitic green sand may have been formed locally, under sub-aërial conditions, where the action of decomposing organic matter played a part (as it must have frequently done) in aiding mineral change. The occurrence, therefore, of glauconitic matter in superficial deposits is no more a proof that Middle Bagshot Beds once extended over the particular locality where it is now met with, than the occurrence of limonite is proof of the former existence in other places of the Upper Bagshot Sands. In each case we have no more than a presumptive probability. In some cases we know positively that such glauconitic material *cannot* have been derived from the Middle Bagshot, because those very beds are known to be a considerable distance beneath the locality where the glauconite is met with. Thus, in the cutting at North Court on Finchampstead Ridges, which is demonstrably in Upper Bagshot Sands, grains of glauconite occur sporadically but conspicuously in the massive sand-beds there exposed; and in places this material is collected in holes and pipes, which simulate root-tubes so remarkably, as to make it almost impossible to doubt that the glauconite was formed *in situ*, through the agency of the organic matter furnished by the decay of the roots, which once occupied the tubes now filled with glauconitic sand. Precisely the same phenomena are met with at Bill Hill, Bracknell, as I have pointed out in the unpublished portion of the MS. (now at the Geological Society's Rooms) of the paper read before that Society on Nov. 12th, 1890. A duplicate series of specimens illustrating this was exhibited at the time. The details which I then gave, and which anyone can verify, show that the beds exposed at these two places have such a lithological similarity (in fact almost an identity), that, if we took lithological characters alone as our guide, we should without any hesitation refer the two series of beds to one and the same horizon. While deferring fuller treatment of

[1] Such as that at Mirk Bottom (see 6-in. Ord. Map), where we have made extensive excavations lately.

[2] See my paper "On Organic Matter as a Geological Agent"; Proc. Geol. Assoc. vol. xii. pp. 227 *et seq.* 1892.

[3] See the cases mentioned in the paper (pp. 43, 44), to which reference has been frequently made in this paper.

this for the present, it may be suggested that a due recognition of the probability that (in the vast period of time that surface-changes have been going on in the higher parts of the London Basin) such materials may have been formed locally, and altogether irrespectively of the particular character of the subjacent terrain, must make us cautious in attaching very much stratigraphical significance to such observed facts. When we meet with glauconitic green sand in a gravel not far from, and resting on beds at a lower horizon than, the outcrop of the "green-earth series" of the Brackle-sham Beds (so-called), there is no difficulty in considering it as derived from them; but obviously this is *not* the case, when "green sand" occurs in gravels, which overlie Upper Bagshot Sands, as in the instance recorded by Mr. Monckton on page 43 of his recent paper "On the Gravels South of the Thames."

Among the many interesting observations recorded in the same paper, those described on page 43 are of special interest, as illustrating some of the processes of surface-change, accompanied with reconstruction of the materials furnished by the Eocene beds and the high-level gravels during later geologic times. It is true that such "accumulations of sand" in the gravels as are there described may by a casual observer be "easily mistaken for the Bagshot Beds themselves." I well recollect the case near Walton Station. Mr. Hudleston pointed it out to me on my first visit to the place, when the cutting was being widened; and though no gravel was seen at that time below it, as it was later on, when the excavations were carried further, I gave it as my opinion that the mass was only sand included in the gravels; and I felt justified in doing so, not merely from the incoherency of the sand and the relation which its rude stratification bore to the later contour of the adjacent country, but also on the ground that I had a short time before observed the same sort of thing at Ascot. In an old note-book I find the following note, dated 1885:—

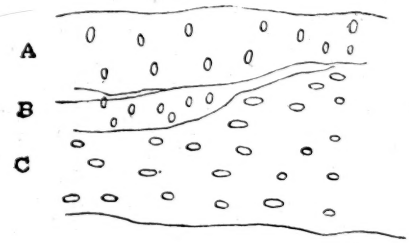
S.W. Railway-cutting east of the Race-course Station. "A thin bed of pebbles with a few angular flints comes on east of the bridge. For some yards this is overlain by a stratified brick-earth. Traced to the east, it expands into an ordinary Quaternary drift-gravel filling the eroded hollows of the clean sand beneath. East of the second bridge is a sand-pit in the clean white sand of the Lower Bagshot. This passes up into a curious contorted mass of fragments of a laminated clay mixed with white sand. This in turn passes under the gravel." With a more limited section the loamy bed here noted might have been easily mistaken for a genuine Eocene sand-bed. The fragments of clay are probably *remanié* from the basement-clays of the Middle Group, which occurred at a somewhat higher level.

In the case of the "somewhat similar deposit in the Brick and Tile Company's brickyard north of Bracknell," it is not easy to see how the section there exposed could have been easily mistaken for a Bagshot Bed, as I saw it in 1887. I find the following note of it, which I made on the spot:—"Top of hill, fine section in sand and

gravel, irregularly bedded with occasional puckers; no trace of oblique lamination seen, strong dip to the north; beds here and there of pebbles and discoloured angular flints, which are strewn through every portion of the sand, thin clay partings (occasionally an inch thick) with intenser colour in the sands just above them." These sandy portions of the gravel passed southwards into a more gravelly mass, with little or no sand; and on a second visit to the place I found that a deep cutting had been made from the face of the pit down into the London Clay. Here the angular gravel was seen in a fresh open daylight section, running beneath the more sandy portions of the mass, and lying upon an eroded surface of London Clay, well down in which was a layer of flint-pebbles dipping about south-east at an angle of 5°. It is quite easy to see how the *quondam* higher Bagshot terrain immediately to the south had, in the denudation of the country, furnished the materials: (1) the flinty material from its surface to form the more gravelly part of the deposit: (2) the sandy material, which (with some admixture of flinty stuff) had been washed down over it, the whole mass being nothing more than a talus-deposit against the flank of a hill, which has since disappeared. But the interest of the section does not end here, for it afforded evidence of glaciation and of the pre-Glacial age of this secondary gravel, as may be seen from the following note made on the spot:—"On the worn and eroded surface of the above lies a glacial deposit (in fact a 'Boulder-clay') with a maximum thickness of 5 feet, full of pebbles and angular flint fragments, generally standing on end." In my paper of 1890 on the plateau-gravels[1] I have referred to this as "an unstratified Boulder-clay, with pebbles standing erect in it, lying upon an older angular and sandy gravel, which lies upon an eroded surface of the London Clay."

A similar deposit occurs at Kintbury, near Newbury, for which I am indebted to Mr. F. J. Bennett of the Geological Survey, who about the same date made the following entry in my note-book:—

Fig. 1.



A. Pebbles in sandy matrix, clayey here and there, pebbles mostly vertical.
B. Pebbles in grey stiff pipe-clay, pebbles also vertical.
C. Pebbles in soft Bagshot sand, mostly horizontal.

In the case at Kintbury, as in that described above north of Bracknell, it is easy to understand how ordinary currents would lay

[1] Q.J.G.S. vol. xlvi. p. 562.

down pebbles and flint fragments horizontally, but not so with the vertical pebbles. A little thought, with the application of the most rudimentary mechanical principles, will however reveal the fact that the same mechanical law applies in both cases. A pebble free to rotate in water upon any axis will assume a permanent direction of its longer axis only in the position of least resistance to the surrounding medium, and this position is attained, when the smallest possible section is opposed to the water. This is equally true, whether the water is flowing past a pebble lying on its bed, or the pebble is itself moving in obedience to the law of gravitation through still water. In the former case the ultimate position of the pebble is *horizontal*, in the latter it is *vertical*; and if it falls into soft mud or silt it will retain this vertical position after coming to rest at the bottom. The conditions, which most readily meet the requirements of the problem before us, are those of a detritus-laden mass of ice floating and gradually melting away in the water of a lake, or the "backwater" of a broad shallow river. In fact, in order to explain the actual phenomena in the one case and in the other, we are thrown back upon such conditions as are implied in the "Thames Straits" hypothesis.

But the facts just described do not stand alone in the immediate locality north of Bracknell, as the following note (made also in 1887) of a new section at Messrs. Lawrence's brickyard close by plainly shows:—

"Upper beds seen in the new pit (about five yards square), a somewhat remarkable deposit containing very pure pipe-clay seams (in some cases three or four inches thick), running very irregularly through a coarse ferruginous sand, not laminated or distinctly stratified. In the sands (generally above the pipe-clay seams) occur layers of bog-iron-ore, and portions of the sand are cemented into concretionary masses by carbonate of iron. Height of section nine feet." The floor of the open pit was formed by the undisturbed pebble-bed.

This was a new exposure of bed (*a*) of the published section (F)[1] of my 1887 paper, "On the Physical History of the Bagshot Beds of the London Basin," and the new section strongly impressed me with the lacustrine character of the bed. I never saw anything like it in undoubted Bagshot Beds. The pipe-clay occurred here in a way in which it is occasionally met with in the gravels (as at Walton), and was not interstratified (as in the true Eocene beds) with regularly bedded sands. I still hold to the view that it records one of the many surface-changes leading to the reconstruction of Bagshot materials, supplemented by other material, which would vary with the conditions locally prevailing at the time. It is more likely than not that the pipe-clay of this and similar deposits, for which I have suggested a later date than the Eocene, may be the insoluble residue of ice-borne chalky detritus[2] from the Kennet

[1] Q.J.G.S., vol. xliii. p. 386.

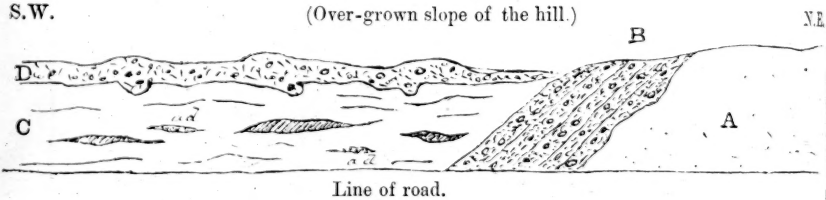
[2] See my paper on "Physical Studies of our Ancient Estuary," GEOL. MAG. for 1891, Dec. III. Vol. VIII. p. 357.

Valley and the Pangbourne Gorge, the ice-rafts which conveyed it to the spot having floated in succession into one of those back-waters of the "Thames Straits," which were caused by some details of surface-contour long since swept away.

This paper has already grown to considerable proportions. I will therefore describe but one more instance of surface-change. The deposits referred to were laid open a short time ago in widening the road-cutting below the church at York Town, Surrey, as indicated in the accompanying diagram :—

FIG. 2.

ROAD-SECTION AT YORK TOWN, SURREY.



Line of road.

A. Ferruginous Upper Bagshot Sands, part of the terrain of the district.

B. Reconstructed materials of the Plateau-gravels, on an ancient hill-slope (talus).

C. Fine irregularly-bedded quartz-sand with occasional discontinuous zones marked by oblique lamination, and here and there some small inclusions (*a*, *d*) of fine angular flint detritus; the whole extending many yards along the road-side.

D. Quaternary gravel of the ordinary character filling eroded hollows on the top of bed C.

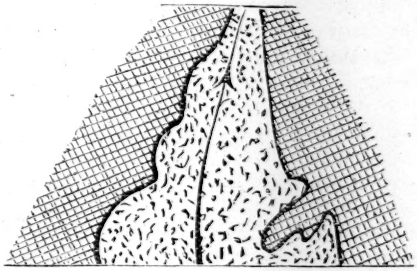
The massive bed, A, calls for no remark. The talus, B (with just that crude stratification which distinguishes a true stream-wrought "talus" from a "scree"), seems to record a very early stage of the sculpturing of the present upland valley-system. But it is to the bed C that the chief interest attaches. I do not hesitate to call it a truly *lacustrine* deposit, and perhaps its position with reference to the overlying secondary gravel and its altitude would justify one in assigning to it a date as old at least as the Glacial Period. Anyhow there could be no possible mistake as to its being a good deal younger than the Upper Bagshot Sands (A) at the northern end of the section. Yet, were it not for the small inclusion or two of fine flinty detritus (*a*, *d*), which might be absent altogether if the excavation were carried a few feet further into the hill, I have little doubt that (standing by itself) it would, on lithological grounds alone, have been claimed by certain writers on Bagshot stratigraphy as a "characteristic section of Lower Bagshot Sands." Cases of this sort are seen to discount largely the value of the purely lithological method, on which so much reliance is placed in certain quarters.

V.—Note on a Coast-Section at the Lizard.

By C. S. Du Riche Preller, M.A., Ph.D., Assoc.M.I.C.E., F.C.S., F.G.S.

At the meeting of the Geological Society on February 8th, Mr. Teall exhibited, as one of the illustrations of his paper "On some Coast-Sections at the Lizard," an eminently characteristic and instructive diagram of serpentine and granite in juxtaposition; and the interesting question whether the granite was intrusive in the serpentine or *vice versa*, was ventilated and discussed, but by no means decided.

From the accompanying sketch of the salient features of that section, it will be seen that the granitic mass, having the shape of an irregular inverted pear in longitudinal section, broad at the base, and gradually narrowing towards the upper end, is flanked on both



Serpentine. *Granite.* *Serpentine.*

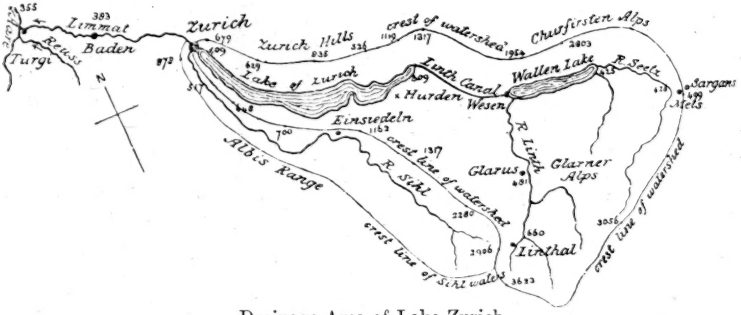
sides by the serpentine which, at one point, on the right side, projects into the granite in the shape of a tongue. In the opinion of some, this last-named phenonenon seemed to lend weight to the conjecture that the serpentine was intrusive in the granite, in which case it would, of course, be younger than the latter. But, in my opinion, that very phenomenon affords conclusive proof of the contrary being the case; for the tongue-shaped projection is only an indication that, at this particular point, the serpentine offered to the intrusive granite greater resistance than at other points of the section, that greater resistance being due to the more advanced state of solidification of the serpentine at that point when the granite erupted. This view appears further strengthened by the fact of the axis of the tongue pointing obliquely downward, in the teeth as it were, of the upward flow of the intrusive granite, which forced back the more yielding, viz. more or less plastic part of the serpentine, and left the already solidified nucleus in the form shown in the diagram. Moreover, to the sharp inward curve of the granitic contact line produced by the serpentine tongue on the right, corresponds an outward curve on the left or opposite side, and the section thus exhibits the ordinary physical conditions of flow, the axis of the granitic complex being, on the whole, a flat curve, determined by the lateral resistance which that mass encountered in forcing its way upwards. The evidently more or less plastic condition of the serpentine at the time of the granitic intrusion also tends to show that the eruption

of both (granting the serpentine to be of igneous origin) took place in the course of the same geological epoch, although this has not yet been fixed. At all events, the grounds above stated undoubtedly warrant the conclusion that, in the characteristic section of the coast east of the Lion Rock, Kynance, the granite was intrusive in, and is, therefore, somewhat younger than the serpentine; and this may, not unreasonably, lead to the conjecture that both are considerably younger than the pre-Cambrian hornblende-schist of the district.

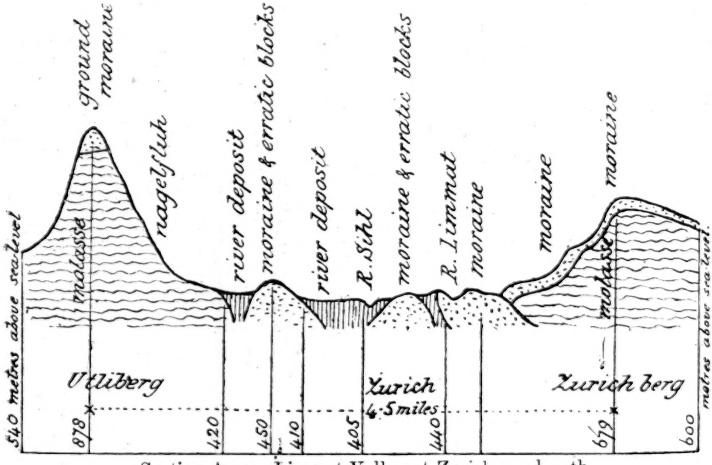
VI.—Note on the Lakes of Zurich and Wallen.

By C. S. Du Riche Preller, M.A., Ph.D., Assoc.M.I.C.E., F.C.S., F.G.S.

In the course of the summer 1892, I had occasion to visit and examine the drainage area of the Lake of Zurich, including that of the Wallensee; and this gave rise to some interesting observations relating more especially to the origin of those lakes, to the high degree of purification of their waters by chemical and mechanical agency, and to some noteworthy effects of certain geological changes in their watersheds.



Drainage Area of Lake Zurich.
The figures indicate the altitudes in metres above the sea-level.



Section Across Limmat Valley at Zurich, $\frac{1}{10000}$th.

1. The drainage area of the lake of Zurich comprises about 420 square miles, the principal tributaries being the rivers Seetz and Linth. Both these rivers rise in the Glarner Alps and discharge into the Wallen lake which, in its turn, drains into the Lake of Zurich by means of the famous Escher-Linth canal. In addition to the discharge of the Wallen lake, which is essentially Alpine in character, the Lake of Zurich receives the waters of the sub-Alpine hills; and the lower part of the whole drainage area is composed of Oligocene molasse and Miocene nagelfluh, the upper part of the series characteristic of the Glarner Alps, viz. Eocene "flysch" (sandstone, limestone and marl), Cretaceous "seewen" limestone, Jurassic (malm and dogger) limestone, and Triassic Buntsandstein, the building up of the successive Jurassic and Cretaceous series being especially conspicuous in the Glarnisch, the central member of this group of the Alps. There can be no doubt that, at one time, the upper (Wallen) and lower (Zurich) lakes formed one lake, the subsequent division being due to the material brought down from the Alps and deposited by the river Linth, thus forming a post-Tertiary intermediate tract of marshy and now reclaimed land, just as the detritus carried down from the Iungfrau group by the River Lütschinen gradually separated the lakes of Brienz and Thun, and formed the intermediate tract of land from which Interlaken derives its name. The difference of level between the Wallen-lake and that of Zurich is 46 feet, the level of the former having been gradually raised by the action of the Linth as already explained, until that river, instead of emptying itself into, and more or less submerging, the tract between the two lakes, was canalized in its lower section and made to discharge into the Wallen-lake. A further characteristic point in relation to the Wallen-lake is the evident connection which at one time existed between it and the Rhine valley, until a low saddle of less than one mile in length and only 60 feet in depth was thrown across the defile between the Glarner and the Churfirsten Alps near Mels and Sargans by the detritus carried down by the river Seetz, thus separating the watersheds of the Rhine and Linth or Limmat systems.

The notion which is still accepted by many, that the principal Alpine Lakes owe their origin to glacial erosion, is completely falsified by the two lakes in question. The greatest known depth of the Wallen-lake is 560 feet, that of the Lake of Zurich 460 feet; but at that depth the bottom only consists of soft mud, and the true or solid bottom is at an unknown, probably much greater, depth. This circumstance must lead to the conclusion that the two lakes owe their origin, not to glacial action, but to a deep rent formed by the shrinkage of the earth's crust and the consequent thrusting and subsidences during the great Alpine movements of Tertiary age. The evidence of this cleft or rent is particularly striking in the Wallen-lake. The axis of the fissure, running in the longitudinal direction of the lakes, is parallel to that of the (Jurassic) Churfirsten Alps flanking the Wallen-lake, and of the (molasse) range of hills flanking the Lake of Zurich, the tributary valleys of the drainage areas being more or less at right angles to it. It was this fissure

which subsequently facilitated the intrusion and purely abrasive action of the glaciers; and these were, therefore, the secondary, but not the primary agency; or, as Prof. Bonney aptly expresses it, the glaciers must be regarded as the file rather than the chisel of nature.[1]

2. The superficial area of the Wallen-lake and that of Zurich is 9 and 34 square miles; their mean depth is 500 and 230 ft. respectively, and their average contents may therefore be computed at 3500 million and 6000 million tons (or cubic metres) of water respectively. It is evident that the Wallen-lake acts in relation to the Lake of Zurich, as a vast storage and clearing reservoir of the waters descending from the Alps; and its purifying action is rendered all the more effectual by the equable discharge of the Alpine rivers due to their origin in the glaciers. In both lakes, but more especially in the larger Lake of Zurich, the natural purification of water is effected by the precipitation of impure matter, favoured by the slow motion of the water; by extensive oxidation promoted by the large surface of water in contact with the air; by the water being kept in motion by occasional storms, and in the Lake of Zurich, moreover, by navigation; by solar heat, which extracts oxygen from aquatic plants; by an aquatic fauna of great variety, which collects at the outflow of drains and streams and feeds on the impure matter with which they are charged; and lastly, by the innumerable quantities of voracious micro-organisms living at the bottom of the lake. The extremely slow motion of the water through the lake as a purifying agency is evidenced by the fact that, the mean discharge from the lake into the river Limmat at Zurich being eight million tons per day, and its contents being 6000 million tons, it takes 750 days, or more than two years, before the water flowing into the lake at the upper end reaches the point of outflow at the lower or Zurich end. It is owing to this, in conjunction with the other chemical and mechanical agencies enumerated, that the water of the Lake of Zurich contains, on an average, only 170 bacteria (collectively about the size of the head of a small pin) per cubic centimetre, and that of the other Swiss lakes has been found to contain even less, *e.g.* the Lake of Constance 58, that of Lucerne 50, and that of Geneva only 38; whereas the spring water of the Zurich hills, especially after rain, often contains as many as 2000 bacteria per cubic centimetre. Having regard to the comparative size and depth of these several Alpine lakes, it may be legitimately inferred that, generally speaking, the larger their superficial area and the greater their depth, the more effectual is the natural process of purification of the water contained in them.

3. An instructive instance of the deviation of water-courses as the result of geological changes is afforded by the river Sihl, which rises in the Glarner Alps of the Canton of Schwyz, beyond the Convent of Einsiedeln, about thirty miles from Zurich. This river at one time emptied itself direct into the lake of Zurich near the upper end, not far from the island of Ufenau and opposite Rapperswil, where the accumulated detritus brought down by it projects into the

[1] The Building of the Alps, Royal Institution, 1884.

lake and forms the tongue of Hurden, about two miles in length and less than half a mile in width. The peculiarly coarse sand and fine gravel which is extensively quarried in this locality and is found at no other point of the lake, affords unmistakable evidence of this being the former outlet of the river. In the course of subsequent dislocations in the upper strata, the old bed was barred, and the river scooped out a new bed through the molasse and nagelfluh of the Albis range of hills, parallel and in close proximity to the lake. The Sihl falls into the Limmat about a mile below the outflow of the latter from the lake, and has an average flow of about one million tons per day, equal to one-eighth of that of the Limmat, although, when in flood, it exceeds at times the mean water volume of the latter. It follows that when the drainage area of the Sihl still formed part of that of the lake of Zurich, the latter must have covered a much larger superficial area than it does now, and that this area had not only a higher level but must have probably extended some twelve miles below Zurich, viz. to the neighbourhood of Baden, where the valley abruptly narrows into a defile of about two miles in length, through which the Limmat rushes to its confluence with the Aare and Reuss at Turgi with a considerable fall.

NOTICES OF MEMOIRS.

I.—The Antarctic Continent.

UNDER the title of "The Chatham Islands: their relation to a former Antarctic Continent," Mr. Henry O. Forbes, F.R.G.S., read a most interesting paper before the Royal Geographical Society, illustrated by maps and figures, in which he gave an admirable account of the Chatham Islands, which lie on the extreme verge of the 180° meridian and 500 miles east of Port Lyttelton, in the south island of New Zealand. Wharekauri, the largest of the group, is 36 miles long, in an east and west direction, and 27 miles broad, from north to south; while Rangiauria, the next biggest, is 9 miles long by 6 miles wide. Since 1840, when they were visited and described by Dr. Dieffenbach, on behalf of the New Zealand Company (see Journ. R. Geogr. Sec. vol. xi. 1841), "now half a century ago, considerable changes have taken place in the outward aspect of the islands. The more or less extensive forests that grew on many parts of the land have to a great extent disappeared to make place for sheep pastures or cultivated fields. The Morioris, or original inhabitants of the Archipelago, whose ranks first thinned by an incursion of Maoris from New Zealand, who for the express purpose of feeding on them had themselves transported thither, have all but vanished, and only a family or two now remain of a race that within the next decade or so will have to be numbered with the Tasmanians and with the wonderful birds that once inhabited with them this isolated spot of land. The Maoris, who since that incursion have possessed, by right of seizure, I suppose, a considerable part of the land, are also fast decreasing in number through disease and drink.

The greater part of the islands, therefore, is owned by European run-holders and stocked with sheep and a few cattle."

After describing the flora of the Islands, and the wealth of Ocean birds which make their residence here, or come to these shores in the breeding-season, Mr. Forbes tells us—

"The whole surface of the islands, especially Wharekauri and Rangiauria, is covered with a bed of peat in places over 40 feet in depth—deeper in the northern arm than in the southern—traversable in safety only by those acquainted with the country; for to the inexperienced eye there seems in most places no difference in the surface which can carry with safety both horse and rider, and that on which the lightest-footed pedestrian could not venture without being engulfed. The surface of some of the larger and wetter depressions in the ground was covered with a brilliant-coloured carpet of luxuriant mosses, emitting an aromatic fragrance, spread out in artless undesigned parterres of rich commingled green, yellow, and purple, and endless shades of these, warning the traveller of the existence of dangerous bogs beneath, and brightening miles of treeless moorland, which, but for these floating gardens, would be uninviting and uninteresting. In many places all over the island this great peat moss is on fire, and has for years been smouldering underground, or burning in the exposed faces of the great pits which have now been burnt out. Dr. Dieffenbach mentions their existence at his visit in 1840, and states that the combustion had begun before 1834, and 'may indeed be traced to a much earlier period, and, in consequence, the soil in the neighbourhood is gradually sinking.' These fires, as far as I could gather, had been burning in one part or another of the island ever since Dieffenbach's visit. Whether the soil has been lit accidentally or on purpose, or has spontaneously taken fire through the decomposition of the peat and lignite, I could not ascertain. A peculiarity in the main island that strikes the visitor very early is the occurrence of many lakes and tarns. These lakes are, for the most part, on the eastern side, at the back of the low hills facing Petre Bay. The largest is 15 miles long, over 40 miles in circumference, and about 10½ miles at its widest part; and, therefore, occupies a large portion of the entire area of the island. Some of these tarns occur even on the highest part of the southern highlands."

Mr. Forbes's main object in visiting Chatham Islands was to discover the remains of a bird, some bones of which had been sent to New Zealand, and which opened up problems of geographical distribution of the highest interest. He writes :—

"Within a few days of my arrival, I had the satisfaction of disentombing from their ancient burial ground in the sand-hills of the Waitangi beach, the complete head and the greater part of the skeleton, certainly all important bones, of the bird to which the head belonged. Associated with them were also those of a tall, extinct coot, and a large raven of an ancient type. I was thus able to confirm my doubtful identification of the bones, that the bird which in ancient days had lived in the Chatham Islands,

was no other than a species of Aphanapteryx, a large and remarkable member of the rail family, which was contemporary with the celebrated dodo in the Island of Mauritius. That island had been till then the only place in the world where the Aphanapteryx was known to exist, and where it had with the dodo preserved its fading race down to about two hundred years ago, when both of these groups passed away and perished for ever from among living things. In the Chatham Islands I found the remains of the Aphanapteryx in kitchen middens of the Morioris, showing that in this region of the world also it had survived down to comparatively recent date, just as the moa had in New Zealand. To find bones of this bird was, therefore, the main object of my visit to the Chatham Islands, but I had in view also to search for evidences of the former existence there of the moa, the apteryx and the weka, characteristic birds of the New Zealand fauna, and to indicate the value and importance to natural and to geographical science, of their occurrence in this island, is the chief reason of my paper to-night." . . . . . .

"Deduced from the study of the distribution of species, it has come to be an accepted law that, 'Whenever we find that a considerable number of the mammals (or what is practically the same thing, of flightless birds) of two countries exhibit distinct marks of relationship, we may be sure that an actual land connection, or at all events an approach to within a very few miles of each other, has at one time existed' (Wallace, 'Island Life,' 2nd ed. p. 74). Now, besides this remarkable Aphanapteryx, I gathered on the Chatham Islands the bones of other birds now extinct there, but identical with species now living in New Zealand, and some of them characteristic of that island, such as the *Kea*, that peculiar parrot which has so changed its diet within recent years that forsaking fruits, it attacks and kills the sheep by eating through their backs into their vital organs; as well as the flightless wood-hen, a species apparently identical with that of South Island (*Ocydromus australis*), a species of owl (*Glaucidium Novæ Zelandiæ*) and the smaller of the two species of New Zealand hawk. In addition to these I obtained a species of swan which once lived (though now extinct) in New Zealand; and the tuatara, a curious and ancient form of lizard absolutely confined to the main group. The occurrence in the Chatham Islands of these species, some of which, like the flightless wood-hen, and the Kea among birds and the tuatura lizard, which could not have crossed the intervening 500 miles of sea with the organs of locomotion they possess, proves that the Chatham Islands must have had at one time a continuous land connection with New Zealand. Its geological structure shows it to be a continental island, for though essentially volcanic, it possesses sedimentary rocks of palæozoic, secondary, and tertiary age, and its flora, which is most closely related to that of its larger neighbours, confirms this opinion as well as the shallowness of the intervening sea where the whalers it is said found soundings.

Confined now to one of the smaller, though once widely spread

over the whole of the Chatham Islands, lives a flightless species of rail of the genus (*Cabalus*) kin to the woodhens, but which is quite unknown in New Zealand, but strangely enough appears again in Lord Howe's Island, far to the north-west, in the Tasman Sea. On the other hand, in the Antipodes, the Auckland, the Macquarrie, and the Campbell Islands, far to the south, we have birds such as the New Zealand woodhen, and a parrot belonging to the red-headed group (*Cyanorhamphus*) common both to the mainland and to the Chatham Islands, as well as many plants common to one or more of these southern islands, and to New Zealand or the Chatham Islands, proclaiming that these island specks are but the fragments protruding above the surface of the sea of a continent or continental island now broken up, and all but totally covered.

It seems pretty certain therefore that 'the Bampton shoal west of New Caledonia, and Lord Howe's Island further south,' and perhaps also New Caledonia and Fiji, formed the northern and western limits of this former extensive continental island, which almost certainly also extended east to the Chatham Islands, and most probably south and east to the Macquarrie and the Antipodes Islands which we may name *Antipodea*.

Now turning for a little to another quarter of the globe, to the region of the Mascarene Islands, we find that François Leguat, the French Huguenot emigrant from Europe to South Africa, who lived in several of these islands, and recorded with great exactness all that he suffered and all that he saw in his "Voyage." He specially describes the *solitaire*, a great flightless pigeon, and also a woodhen, or *gelinote*, with a red beak and red borders to its eyes. Remains of this bird have been discovered along with those of the solitaire, and have been determined to belong to a great species of rail, nearly related to the woodhens of New Zealand. From its hostility to red the generic name of *Erythromachus* has been applied to it.

The Island of Mauritius, 95 miles to the south-west, was inhabited by the great dodo (*Didus ineptus*), which was also a gigantic flightless pigeon, living on the ground. It was a very near relative of the solitaire, as was finally proved by an examination of the large collection of its bones received in Europe in 1866, among which there were several of another bird then unknown, and which continued to be so till the year 1868, when Herr von Frauenfeld discovered in the library of the Emperor of Austria the picture of a remarkable bird, a tall crane or woodhen, so closely agreeing with the description of the gelinote given by Leguat as to leave no doubt as to its identity. The bones found mixed with those of the dodo turned out unquestionably to belong to this fine woodhen, which was named *Aphanapteryx*. Both birds, however, were of the closest kin to each other, and must have had a common ancestor; but their nearest relatives elsewhere are the wekas, or woodhens, of New Zealand. At the present day there are no birds in either Rodriguez or Mauritius nearly related to the Ocydromine group of

the rails. Professor Newton also and his brother, Sir Edward, consider it 'impossible on any other reasonable supposition than that of a common ancestry to account for the distribution of the animal forms that they present. These authors are compelled to the belief that there was once a time when Rodriguez, Mauritius, Bourbon, Madagascar, and the Seychelles were connected by dry land which we may name Mascarenia, and that that time is sufficiently remote to have permitted the descendants of the original inhabitants of this now submerged continent to become modified into the many representative forms which are now known. . . . . That the solitaire of Rodriguez and the dodo of Mauritius, much as they eventually came to differ, sprang from one and the same stock, seems a deduction so obvious that the authors can no more conceive anyone fully acquainted with the facts of the case hesitating about its adoption' ('Voyage of François Leguat,' vol. ii. p. 356—Hakluyt Society, 1891).

On comparing the bones of the *Aphanapteryx* brought from the Chatham Islands with those of the Mauritius bird, I have found them to be so closely related as to be almost inseparable. Indeed, these bones from Wharekauri and Mauritius, over 120° of longitude apart, are more nearly related to each other than the *Erythromachus* of Rodriguez (an island of its own archipelago, only 95 miles distant) is with the *Aphanapteryx* of Mauritius.

The question arises how came they to inhabit such widely separated regions? There is only one deduction: the members of the genus must have reached their respective homes by some continuous land connection between the two places. In order, however, to make as clear as possible the route by which Mr. Forbes believed these descendants of a common ancestor reached habitats so far apart, he discussed the distribution of life in other regions of the hemisphere.

In the southern regions of the great continents, in the southern part of South America, in South Africa, in Australia, and in New Zealand, we have forms, either still living or now extinct, that are so closely related as to indicate that they have sprung from a common ancestor. In New Zealand there occur the remains of the moa, which stood over 10 feet in height, a member of the ancient family of the ostriches. It lived down to comparatively recent times and goes back to about the newer Pliocene or Pleistocene age. We have also here a somewhat aberrant form of the same family, the kiwi, or apteryx, still living. In Australia there existed a now extinct genus of the same family, the *Dromornis*; and two genera alive, the emu and the cassowary—the latter extending into New Guinea and some of the surrounding islands. In Madagascar we find in a fossil state the bones of a large species of the same group, the *Æpyornis*; I have lately examined specimens of its bones recently received in the British Museum, whose similarity to those of the moa is so great that if they had been discovered in New Zealand they would, I believe, undoubtedly have been referred to a species of moa. In Africa we have the aberrant ostrich. While in

South America, where the rheas occur, there has lately been discovered in the Tertiary of Patagonia the remains of great flightless birds belonging to the *Struthionidæ*. This family is, therefore, practically confined to the southern hemisphere with few exceptions. Again, the family of the Trogons is confined almost entirely to regions south of the equator. The penguins (*Spheniscidæ*) form a group still more closely restricted to Southern latitudes. Two ancient forms, *Palæeudyptes*, *Palæospheniscus*, are known in the early Tertiaries of New Zealand and of Patagonia. They now range from South America, South Africa, Australia, and New Zealand, to the Antarctic Islands. To the latter, *i.e.*, the Falkland, the Crozet, and Kerguelen Islands, the family of the *Chionidæ*, a peculiar group of white birds related to the plovers, is also restricted. The great group of the parrots (*Psittacomorphæ*) have, as pointed out by Professor Huxley long ago, related, but very distinct families, in Australasia and in South America; they are feebly represented in India and South Africa, and have only a straggler here and there in North America. They are essentially a southern group.

Turning to another section of the animal kingdom, we find wonderfully developed in Australia, and in New Guinea, and some of the neighbouring islands, the marsupials, or kangaroos and wombats, a group occurring nowhere else except in South America; but the marsupials living now in Australia are not very nearly allied to those in South America. In the Pliocene age, however, there lived in East Australia gigantic forms of the family, the *Diprotodon*, the *Nototherium*, the marsupial lion (*Thylacoleo*), and others; and quite recently remains of the genera *Prothylacinus*, *Amphiproviverra*, closely related to the Tasmanian Devil (*Thylacinus*), and to other *Dasyuridæ* of both Tasmania and Australia, have been discovered in the Eocene of Patagonia.

Another very extraordinary group (the Edentata), the ant-eaters, sloths, and armadillos, now live in the southern parts of South America. In more ancient times the order was represented by still more bizarre forms, such as the *Glyptodon*, the *Mylodon*, and the *Megatherium*. In South Africa are the Aard-varks (*Orycteropidæ*), while in India, and some of the Indian Islands, we find Pangolins, or ant-eaters (*Manidæ*), which are all members of the same order. They are scarcely known in the northern hemisphere, and then only in its warmest regions; but they have been recently found fossil in Upper Miocene beds in Samos by Dr. Forsyth-Major.

The well-known examples of Amphibia, confined to Notogæa, or the Southern Hemisphere, we have *Cystognathidæ*, found in Australia, Tasmania, and South America; and of freshwater fishes, we have the *Haplochitondæ*, or southern salmon, and the southern pikes (*Galaxiidæ*), families both unknown north of the Equator, occurring in New Zealand, Chili, Patagonia, and the Falkland Islands.

If we turn to plants, and takinggroups that are confined, or nearly so, to the Southern Hemisphere we find among the *Saxifrageæ*, that two of its tribes (*Escalloni*, consisting of seventeen genera,

and *Cunonieæ*, with eighteen genera), are confined (almost) to New Caledonia, Australia, Tasmania, New Zealand, the Mascarene Islands, South Africa, and South America. Of their thirty-five genera two only cross the equator into the northern hemisphere. Of the *Proteaceæ*, composed of forty-nine genera and nine hundred and fifty species, only twenty-five species cross the Equator, otherwise they are distributed to all the southern continents with Madagascar, Tasmania, New Zealand, and New Caledonia; but they occur in Miocene and Cretaceous strata in Europe.

Mr. Forbes, after discussing the opinions of Wallace, Darwin, and Blanford for and against an extensive land area in the Antarctic Ocean, remarks:—In considering the number of genera, or species of the same groups that have reached the three terminal regions of the land in the southern hemisphere, it seems almost too remarkable to believe that it should have been the same forms in more than one that have alone been able to survive the vicissitudes of retreat against 'the pressure of more specialised types' through such different lands from the north to the south, without leaving often a single representative north of the equator and yet should have succeeded in resisting being driven right into the southern sea. It is besides a biological axiom that two identical species have never independently arisen in distant localities.

The Author of the paper then proceeded to adduce the evidence brought forward by Huxley in regard to the distribution of the Peristeropodes (of the Gallinaceæ), and of the Parrots, and that by Prof. W. K. Parker, our most penetrating embryologist, and the foremost of the interpreters of those passing structures in the embryo, which appearing but for an hour, and vanishing as if they had never been, yet so surely proclaim its pedigree and inheritances, in his paper on the Ægithognathous birds, in which are described the affinities between (among other groups) the Australian *Gymnorhinidæ* and the South American *Dendrocolaptidæ*—groups unknown north of the equator.

This evidence, he considers, of the weightiest kind in support of the hypothesis that there existed a large land extension round the South Pole joining South America and Australia, and approaching to, or intermittently only connected with, South Africa, possessing a genial climate, on which the progenitors of these groups common to Australia and South America, which have now lost their nearest relations, could multiply, became modified, and eventually migrated northward on the return of colder epochs, or on account of the subsidence of the land.

Before considering how far the presence of such an austral continent would explain the distribution of life, Mr. Forbes referred to the climate of the southern hemisphere during the later geological periods. He referred to the evidences of glaciation in South Africa, in South America, in Australia, and in New Zealand, dating from a comparatively recent epoch. Mr. Forbes accepted Sir Robert Ball's emphatic declaration: 'It is an essential doctrine of the astronomical theory of the ice age that the respective glaciations of the two

hemispheres were *not* simultaneous,' but were alternate. And 'if it could be shown that the ice ages in the two hemispheres were concurrent, the astronomical doctrine would have to be forthwith abandoned.' This glacial age, of which evidences have been found in the southern continents, must, if Sir Robert Ball's assertion be correct, have taken place during a genial period in the northern hemisphere. Now during the Miocene age there was such a warm period (doubtless due to a period of high eccentricity) when a luxuriant flora flourished in the Arctic regions to within $8\frac{1}{2}°$ of the Pole.

"The outlines of this Antarctic continent it is of course impossible to trace with anything approaching to accuracy till we are in possession of a larger number of soundings. But it is not unlikely that the great meridional masses of land—or world ridges—which are probably of primeval antiquity extended to meet prolongations running northward from the Antarctic continent. There is some evidence that the direct union of the Antarctic continent with South Africa was not for so prolonged a period as with the others. The presence of the *Aphanapteryx* and other ocydromine birds both in Mascarenia and in Antipodea supports other evidence pointing to an extension of that area south by Marion and Kerguelen Islands, and of New Zealand south, by way of the Macquarrie, Auckland, and Antipodes Islands. It is interesting to observe that the great Pacific trough to the east of the longitude of New Zealand extends far south into the Antarctic land."

Mr. Forbes next discussed the evidence derivable from the flora of the islands in the Antarctic Ocean, and argued that it also indicated a more extensive land in those seas.

Mr. Forbes's conception of the form of this Antarctic continent is thus described:—"The Geological evidence shows that New Zealand was separated from Australia during all the Tertiary period, and that East and West Australia existed as two islands during a portion of the Cretaceous and Tertiary ages; so that in the early Tertiary period, at least, there were three separate islands, West Australia, East Australia, and New Zealand, the two latter with southern extensions. The New Zealand eastern shore-line extended not improbably from the Chatham Islands, by Young Island, to Victoria Land, where the Pacific trough runs far to the south, and northwest from the Chatham Islands, by Norfolk Island, near to—and, perhaps, including—New Caledonia and Fiji; southwards, by Lord Howe's Island to the west of Stewart and Macquarrie Islands, where turning south and westward, it united with the eastern shore of East Australia, prolonged south to the Antarctic Land; its northern extension probably connecting the Great Papuasian Land (New Guinea, the Solomons, New Britain, and New Ireland) across Torres Straits—West Australia at this period, and for a long time previously and after, remaining a large and isolated island. The western shore of East Australia then ran southward and westward to Wilkes Land, where, about the longitude of 90° E., the trough of the Indian Ocean extends south towards the Pole, once more trending northward by

Kemp Island, and Kerguelen Land to join the Ethiopian region, either by the Mascarene Island-continent, with perhaps an African commissure, or, perhaps, for a time with that continent directly. The South Atlantic Ocean would seem to extend far south into the Antarctic separating the Ethiopian prolongation from the South American enlargement, which included the Falkland Islands, South Georgia, and the Sandwich Group, to Graham and Alexander Lands. But our knowledge of the sea floor south of Africa is still very imperfect."

"If it be true that Ice Ages and Genial Ages were alternate in the two hemispheres, as Sir R. Ball affirms, then when the Miocene Southern Ice Age was at its height, the life in this southern continent would be driven towards or across the equator, and when in the late Miocene and in the Pliocene, the warm period (corresponding to the growing cold period of the northern hemisphere) was advancing, and the land surface fit for peopling was increasing, there would be a slow return to the Antarctic land. Whether or not there was such a cold period, there must have succeeded a very mild age—almost certainly during the height of the glacial age of the northern hemisphere—to enable the fauna and flora now common to the terminal areas of the three great continents to develop on a southern land and to intermingle."

"The monotremes and marsupials in Australia are supposed by Mr. Wallace to have come to Western Australia at a very ancient period from Asia, *viâ* a land connection across the Java Sea, and to have entered East Australia only in the Tertiary age after the union of the two islands. Nearly all our fossil remains, however, of these groups are found in East Australia, and their present distribution is in northern Austro-Malaya and Australia. Now there have been found in Patagonia, as already stated, in early Eocene times fossil remains, nearly allied to the carnivorous Thylacine of Tasmania and the dasyures, that occur both in Pliocene and Pleistocene beds in Australia, or live now in Australia and Tasmania. No fossil remains of these southern forms have been found elsewhere out of Australia and Patagonia. It is not therefore at all improbable to suppose that the South American Thylacine-like forms multiplied and developed in the Southern Continent during the warm age of the southern—and reached East Australia from that continent, then spread north through Tasmania into New Guinea and the Papuan Islands. Why they are not found in New Zealand is difficult to say; some temporary subsidence or other barrier may probably have prevented their reaching it. It does seem to me strange if the marsupials reached Australia *viâ* the Java Sea, Timor, and the belt of the Austro-Malayan Islands to the west of it, that with the exception of a *cuscus*, which may not improbably have been introduced, there are no marsupials in any of the South-Eastern Austro-Malayan Islands, where there are no enemies not found in New Guinea and Australia, especially in Timor, which is so Australian in its climate and vegetation. The ancestors of the present marsupials in South America, which have no near

affinity with the present Australian forms, came no doubt *viâ* North America from Europe. The ancestors of the cassowaries, moas, and kiwis are supposed by Mr. Wallace to have come from New Guinea into the north of East Australia, and to have spread thence to New Zealand in Cretaceous times. Again the Eocene of Patagonia has produced the remains of giant struthious birds—*Brontornis burmeisteri*—which can have been the ancestors on the Antarctic Continent, not only of the Australian and New Zealand forms, but of all the tridactile forms—of the *Æpyornis* of Madagascar, as well as the Neotropical rheas. Recent remains of *Æpyornis* received at the British Museum show in the tibia, or leg bones especially, a very close resemblance to that of the moa. The metatarsi of the moa and *Æpyornis* also show many points in common. The Madagascar, the Australian, and the New Zealand Ostriches would at least seem to have had a common ancestor."

"That a current of life has flowed from south to north, as well as *vice versâ*, has strong support lent to it by the results of Sir William Macgregor's recent botanical collections in New Guinea. In the highland vegetation of that country, along with an extensive display of heaths and whortleberries—forms of vegetation which are scanty in Australia—there is also a marked preponderance of far southern types, belonging to Australia, New Zealand, and Antarctica. In Borneo also have been found plants common to the Papuan highlands, and also plants from high southern latitudes. So many plants from high southern latitudes of common origin, typical of Tasmania, of continental Australia, of the Southern Ocean, and of Patagonia, point to a land connection of portions of New Guinea with an Antarctic continent. As there are, moreover, abundant evidences of great volcanic action over all the region, in New Zealand, South America, Mascarenia, and the Antarctic Islands, the permutations and combinations of the ups and downs of these lands, the openings and closings of the gates, paths, or stepping stones, are beyond our computation."

Mr. Forbes sums up in these words :—

Shortly, therefore, 'it is highly probable,' as Mr. Blanford says, 'that many forms of terrestrial life . . . originated in the southern hemisphere ; and . . . it is far from improbable that the Antarctic continent was the original area of development.' It seems to me, therefore, highly probable that Professor Huxley's divisions of the Globe, in which he is followed by Professor Kitchen Parker, according to the distribution of life into a northern and into a southern land—an arctogœa and a notogœa—will turn out to be the two fundamental biological divisions of the Globe. That there was a centre of development at both poles, and the wanderings and migrations of the fauna and flora, northwards or southwards, from age to age, and from one side of the Equator to the other, were regulated by glacial and genial periods, and from east to west by the elevation and subsidence of an extensive land, in the southern hemisphere as in the northern.

These deductions as to an Antarctic continent, made on biological

grounds, are supported by the depth of the circumpolar sea, so far as it is known. The submarine shelf of the Austral land slopes northward all round the shores of the known lands more gently than along any other coast, and would seem to indicate that, if elevated, the land would form in great extent a continuation of the three primal ridges of the globe southward, coalesced and spread out round the Pole, with, between these arms, the terminations of the great and permanent ocean troughs. How far these hypotheses may be substantiated or refuted by future researches it is difficult to say; but the discovery of *Aphanapteryx* bones on the Chatham Islands must always remain an important fact in the solution of this most difficult and intricate question."

II.—The Supposed Quaternary and since Submerged Volcano of Mergellina, at Naples.[1] By Chev. W. P. Jervis, F.G.S., etc.

On entering the Bay of Naples by steamer the first thing which must have struck every geologist—leaving aside Vesuvius for the present—is the line of flat-topped hills stretching along the northern shores of the Bay, from Cape Posillipo to the Chiatamone, above the Castel dell'Uovo, their summits in no place exceeding from 160 to 200 metres in height, except at the Castel Saint'Elmo (224m.) while they extend inland from the Vomero to the culminating point at the old Camaldoli convent, above Pianura (455m.). These hills are essentially constituted of irregular strata of ochreous-yellow volcanic tufa of various tints, passing on the one side to pale yellowish white, and on the other to yellowish brown. This tufa is accompanied by frequent alternating beds of extremely fine volcanic ashes, and others often exclusively formed of impure-white or ash-grey pumice in angular pieces, ranging from less than a quarter-of-an-inch to several inches across, and adhering slightly together, though easily separated by the hand. Fragmentary pumice also exists in a certain proportion as a constituent of the volcanic tufa itself, in such case partaking in general of the coloration of the rock in which it is imbedded, being of a yellowish brown, and only in some places white, for instance near Piedigrotta. Sometimes the pumice is dark yellowish-brown, this variety, as well as the paler kind, being much decomposed, or what might be called in ordinary language rotten, so as to crumble when an attempt is made to detach it from the enclosing rock, for it is only when the pumice retains its original whitish or ash-grey appearance that it preserves any consistency or is of any economic value.

It will be immediately observed, on the most superficial examination, how remarkably irregular is the bedding of even the thickest strata, as they rapidly thin out, and often disappear altogether, to be replaced by others of very different lithological structure. As if to add to such irregularity, the dip of the beds is very varying and inconstant; in one spot it appears to be horizontal, a few yards beyond it is not unfrequently undulating, and further on inclined

[1] From the "Mediterranean Naturalist," October 1, 1892.

at a high angle—suggesting the probability of upheaval and giving-way of the strata through local volcanic agency, exerted at a very slight depth below the surface and frequently repeated.

In quarrying the tufa as a building-material, invaluable on account of its cheapness (five pieces of a roughly parallelopipidal shape, together measuring about two cubic feet, being worth only a franc) —the greatest difference is found to exist in the coefficient of resistance to pressure and crushing strain, according to the locality and series of beds whence the stone is procured. One point, however, is found in common; it was all bedded as a littoral deposit and in shallow sea-water; in confirmation of this, large oyster shells may be sometimes met with in it. Lead-grey volcanic tufa is largely developed at the southern entrance to the Bay of Naples, around Sorrento, but it is nowhere to be met with on the north side of Vesuvius, or beyond the region I am describing in the direction of Pozzuoli or in the islands of Procida or Ischia.

Topographically the tufa hills of Posillipo and Naples continue in the direction of the old Camaldoli convent, in which neighbourhood scoriaceous and other lava is largely developed; in other directions these hills have no connection with any others, for towards Vesuvius and in the direction of Caserto they die off gradually, and the plain at their foot is but slightly above the sea-level. From Cape Posillipo as far as the Vomero, above the Grotta di Pozzuoli, the hill is saddle-shaped, with a long, narrow ridge at the summit, and sloping down at a considerable angle on each side to the base. At the distance of half-a-mile from the mainland beyond Cape Posillipo is the little islet of Nisita, 180m. high, which is simply a small volcanic cone, with a crater broken down on the side looking towards the entrance of the bay, the rock consisting of volcanic tufa.

It has always been a question to me whence this prodigious mass of tufa overlooking the Bay of Naples was ejected. Certainly not from Vesuvius or Monte Somma, far less from certain other volcanoes, such as the Solfatara, the Astruni, or Agnana, which have not the least topographical connection with the hills of which I am speaking, and no denudation has taken place to authorize such a supposition; most improbably also from Nisita, which, besides its insignificant proportions, occupies too eccentric a position. For my part I have for many a long year been led to believe that this tufa was produced by a volcano situated at a short distance from the Mergellina (part of Naples), but now submerged and no longer recognizable. Possibly we may be shortly able to clear up this difficulty, a most unexpected discovery having been recently made in the very heart of Naples, and one to which I am led to attribute considerable geological importance.

At the present time a large main sewage drain is being driven through the soft tufa rock from the south-eastern part of the city to the vicinity of Fuorigrotta, outside the city to the north-west. Under the Villa Montfort, at the lower end of the Parco Grifeo, close to the Corso Vittorio-Emanuel, the sewer is situated at the level of 13m. 70cm. above the sea; 250m. farther north, close to

the new International Hospital, it is slightly more than 13m. above the sea-level; the surface of the ground above being respectively 100m. and 65m. at the points alluded to. Just under the Villa Montfort trachyte rock was met with, 40m. of it having been already bored through, while at the surface not a trace of such rock was ever suspected to exist, volcanic tufa alone being seen; nor did it ever come under any person's observation that trachyte should anywhere be met with in the tufa hills I am describing. The trachyte, which I have carefully examined, is of a dark lead-grey or bluish colour, and equal to the hardest and most compact kind found in any part of the Phlegræan Fields, being identical in structure to some met with at Pozzuoli, and like it enclosing small crystals of sanidine or glassy felspar. Attiguous to the trachyte, and for a certain distance from it to the south-east, the tufa is very pumiceous, and large loose blocks of trachyte of a yellowish tinge are to be found imbedded in the midst of the tufa, from which they do not essentially differ in colour. Sometimes the tufa adheres firmly to the trachyte, which might lead us to suppose that the latter must have fallen on the surface of the tufa before it had had time to be perfectly cooled. M. Giusti, the engineer in charge of the works at this point, kindly gave me the following data. After leaving the ordinary yellow tufa common to these hills, some beds of good yellow tufa were pierced, then rather clayey tufa; after which dark-yellow tufa containing large fragmentary pieces of undecomposed pumice, a variety peculiar to this neighbourhood; then a gentle synclinal of white tufa, each of these several beds being but a few metres in thickness. After this followed 30m. of pumiceous tufa, containing large loose blocks of trachyte, followed by the trachyte rock *in situ* above alluded to.

Have we not here the evidence of the existence of a volcanic eruption of Quaternary age, though it cannot yet be decided whether it ever reached the surface, or whether there were not some lateral veins, or a blind dyke, which forced its way up through the already existing tufa. The subject offers much interest, and I hope some day to be able to communicate further information regarding it. I am led to conclude that the central crater of this volcano must have been situated within a mile of the present coast-line in a spot now occupied by deep water, the cone having subsided since the Quaternary period. Should my conjecture be found admissible we might apply the name of "Mergellina volcano" to this trachytic ejection, and we might then be authorized to regard the tufa hills of Naples and Posillipo as having had their origin thence. Both the trachyte and the yellow tufa are rocks common to all the volcanoes of the Phlegræan Fields and the neighbouring islands, while leucitic rocks characterize Monte Somma, and augite and leucite Vesuvian rocks.

While speaking of the neighbourhood of Naples I may just give the results of a few very careful observations I made this spring of the temperature of several thermal springs and fumaroles, and compare them with former studies.

Casamicicola, Island of Ischia.—*Acqua del Gurgitello*, February 1869, 84°. c. (Jervis); 10th May, 1892, 84°. c. (Jervis).

Lacco Ameno, Island of Ischia.—*Acquadella Rita* 1833, 70°. c. (De Rivaz); 1835, 61°. c. (Guarini); 11th May, 1892, 66°. c. (Jervis).

Barano d'Ischia.—*Fumarola di Saint' Angelo*, on the beach; February 1869, 100° c. (Jervis); 11th May, 1892, 100°. c. (Jervis).

Casamicicola.—*Stufe* or *Fumarole di Castiglione* 1822, upper fumarole 56°. c. lower fumarole 66°. c. (Del Giudice); 11th May, 1892, lower fumarole 56°. c. (Jervis).

Pozzuoli—*Fumarola della Bocca della Solfatara*, February 1862, 93°. 4—96°. 5 c. (Deville); June 1865, 77°.—96°. c. (Deville); 1865, 96°. c. (Fouqué); July 1867, 115°. c. (Gorceix); January 1869, 92°. c. (Jervis); 12 May, 1892, 95°. c. (Jervis).

Naples.—*Stufe di San Germano*, 1856, 64°.—93°. c. (Deville); 1857 and 1882, 61°.—97°. c. (Deville); 1857 and 1862, 61°.—97°. c. (Deville); July 1869, 85°.—96°. c. (Deville); May 1892, 86°. c. (Jervis).

Naples.—*Acqua del lago prosciugato di Agnana*, May, 1892, 69°.—73°. according to place (Jervis).

Naples.—*Grotta del Cane*, May 1892, 38°. c. (Jervis).

Turin, *September*, 1892.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 22nd, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Jaw of a new Carnivorous Dinosaur from the Oxford Clay of Peterborough." By R. Lydekker, Esq., B.A., F.G.S.

The Author describes a fragment of the left side of a lower jaw of a Carnivorous Dinosaur from the Oxford Clay of Peterborough, indicating a new genus and species, which he names *Sarcolestes Leedsi*.

2. "On a Mammalian Incisor from the Wealden of Hastings." By R. Lydekker, Esq., B.A., F.G.S.

In this paper a small rodent-like tooth from the Wealden of Hastings, belonging to Sir John Evans, K.C.B., is described. It is probably the front tooth of one of the mammalian genera found in the Purbeck Beds, as may be gathered from American specimens.

3. "On an Intrusion of Muscovite-biotite-gneiss in the South-eastern Highlands, and its accompanying Thermo-metamorphism." By George Barrow, Esq., F.G.S., of the Geological Survey. (Communicated by permission of the Director-General of the Geological Survey.)

The area to which this papers refers lies in the north-eastern part of Forfarshire, and is drained by the two Esks. The Author first describes the distribution, mode of occurrence, and petrological characters of the intrusive masses. In the north-western portion of the area the intrusive rock is always a gneiss, and occurs in thin tongues which permeate the surrounding rocks. Towards the south-

east these tongues amalgamate and form large masses, in which the foliation is less marked. Moreover, in this direction the large masses are often fringed with pegmatite, especially on their southern and eastern edges. Where the rock is a gneiss, it is composed of oligoclase, muscovite, biotite, and quartz, but contains no microcline. As the gneissose character becomes less marked, the oligoclase diminishes in amount, and microcline begins to appear, especially towards the margins of the masses. In the most south-easterly of these microcline is greatly in excess of oligoclase.

The differences in structure and composition of these masses are believed by the Author to be due to the straining off of the crystals of earlier consolidation during intrusion under great pressure. The still liquid potash-bearing portion of the magma was squeezed out and forced into every plane of weakness in the surrounding rocks; and that portion of it which contained the highest percentage of potash finally consolidated as pegmatite.

Special attention is directed to the distribution of pegmatite. This rock is widely distributed in the Southern Highlands, and cuts across every known system of folding. It is consequently newer than any member of the metamorphic series.

The surrounding metamorphic schists are next dealt with. These are remarkable for their highly crystalline condition, and also on account of the presence of many minerals known to occur in regions where thermometamorphism has taken place. The characters of the more important minerals are described in detail. The rocks of the metamorphic area become less and less crystalline as they are followed towards the Highland border. Three zones, characterized respectively by the minerals sillimanite, cyanite, and staurolite, have been roughly mapped. The more important rocks found in these zones are described in detail, and evidence is given to show that the boundaries between the zones do not in all cases coincide with the strike of the rocks. Thus, a thin bed of quartzite, which retains its character in consequence of the simplicity of its chemical composition, may be followed through all the zones; whereas the bed adjacent to it is in the outer zone a staurolite-schist, in the intermediate zone a cyanite-gneiss, and near the contact with the igneous rock a coarse sillimanite-gneiss. Evidence is given to show that the original rocks formed a sedimentary series.

The phenomena are compared with those of other areas where thermometamorphism has taken place; and the conclusion is reached that the differences are of *degree* rather than of *kind*. The special features of the area in question are attributed to the depth at which the change was produced.

The singular Fucoid-like impression, long known from the older Palæozoic Rocks of North America, under the name of *Arthrophycus Harlani*, has just been sent home from the Gold-Coast-Colony, West Africa, by Mr. Ferguson to Professor J. W. Judd, F.R.S., who has presented a specimen to the British Museum (Natural History), Cromwell Road, S.W.

OBITUARY.

THOMAS GABRIEL BAYFIELD, OF NORWICH.

BORN 17 JANUARY, 1817. DIED 27 MARCH, 1893.

MANY who are engaged in scientific and literary work in the city and county of Norwich and Norfolk will learn with regret the death of Mr. Thos. Gabriel Bayfield, which occurred on 27 March, at his residence, Bracondale. The deceased gentleman, who had attained his seventy-seventh year, was the son of an ironmonger, who carried on an old-established business in Magdalen-street. As a lad he was sent to Mr. Brooke's school, at the Greyfriar's Priory, but was afterwards removed to the seminary conducted by Mr. Norman, in Golden Dog-lane, where he acquired a good knowledge of Latin, Greek, mathematics, and the ordinary English subjects. Upon leaving school, at the age of fifteen, he entered the Magdalen-street establishment, and worked for two years with his father, who had originally intended him for the medical profession. His father died in 1834, and young Bayfield remained to assist in the business, which for many years was carried on under the style of Ann Bayfield and Son. In his school-days the lad formed the acquaintance of B. B. Woodward, afterwards Queen's librarian, and S. P. Woodward, the subsequent author of a Manual of the Mollusca, both sons of Samuel Woodward, of Norwich, and from them he imbibed a love for archæology and natural history. Possessing an enquiring mind and a memory of remarkable retentiveness, he amassed a rich store of knowledge on archæological, geological, and other scientific subjects. He was regarded as an authority on ancient seals, and rendered great assistance to Dean Goulburn in the compilation of his work on Norwich Cathedral. Mr. Bayfield devoted much attention to electro-types, of which he made many specimens; he also spent considerable time in botanical research, and was much sought after by local scientists, by whom he was greatly respected. In geology he laboured at the Chalk and Norwich Crag, and made a valuable collection of fossils, those from the Chalk being subsequently acquired by the British Museum. He was one of the most active members of the Norwich Geological Society, an enthusiastic member of the Norwich Science Club founded by Dr. J. E. Taylor, whom he succeeded as President, and he was also President of the Norfolk Naturalists' Society. Upon relinquishing business, about sixteen years ago, Mr. Bayfield obtained the appointment of Master of the Blind School, but after discharging the duties of that office for about seven years his health failed, and he retired into private life. He still retained an affection for scientific pursuits, and took great interest in his large and varied collection of antiquities. Mr. Bayfield leaves a widow (the eldest daughter of the late Samuel Woodward), a son, and two daughters. —*Eastern Daily Press.*